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ABSTRACT

The purpose of the document is to explain how managers can use cost and output data to obtain information which will help them utilize resources wisely. It points out what numbers of manager needs to know and distinguishes between data and information. Data must be organized to enable comparisons to be made and relationships identified. Conceptual problems in collecting and interpreting cost and output data are discussed. Much of the information does not require a formal application of statistical procedures, and while the remarks are directed toward government managers, they have wider application. Attention is given to defining analysis, who performs analysis and why, techniques of analysis, cost analysis, data analysis, and establishing a data base. The concluding section provides three case histories exemplifying uses of analysis. (Charts, graphs, and tables are used to illustrate concepts.) (AG)

ANALYSIS

FOR MANAGERS OF PEOPLE AND THINGS

ASSISTANT SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301

COMPTROLLER

FOREWORD

This text was developed as a guide to assist DoD Managers in their role as decision makers. Systems analysis is widely used to improve the quality of high impact decisions, for problems of force-mix or weapon system acquisition, but thousands of decisions are made daily by managers at the operating level without the benefit of a systematic consideration of the problem. These daily decisions total billions of dollars. All of us must learn to analyze our problems, to develop alternative courses of action for their solution, and to determine the costs and benefits of each alternative. We must constantly be aware of the importance of analysis in our daily managerial tasks and we must make the use of analysis a habit.

I am convinced that the opportunity for significant savings exists at each managerial level and that this opportunity can be successfully exploited by the proper use of analysis. Our nation faces a critical period, beset by problems of shrinking resources, inflationary erosion, and rising personnel costs. The requirement for a strong defensive force has not changed, only its application has. Our department must simply do more with less. Each DoD decision maker should be cognizant of his responsibility to exploit every opportunity to ease this crisis. This text was developed for that very task, i.e., to help stretch our resources by improved analysis.

There will be no new reporting system concerning the use of analysis, no one is going to be looking over your shoulder to insure the use of this text. Rather, I rely on your judgement and professional pride to motivate you to employ this text in a routine fashion. I suggest you make the use of analysis your criterion of a job well done, of a decision founded on reason rather than emotion.

Terence E. McClary

Terence E. McClary
Assistant Secretary of Defense

ANALYSIS FOR MANAGERS OF PEOPLE AND THINGS

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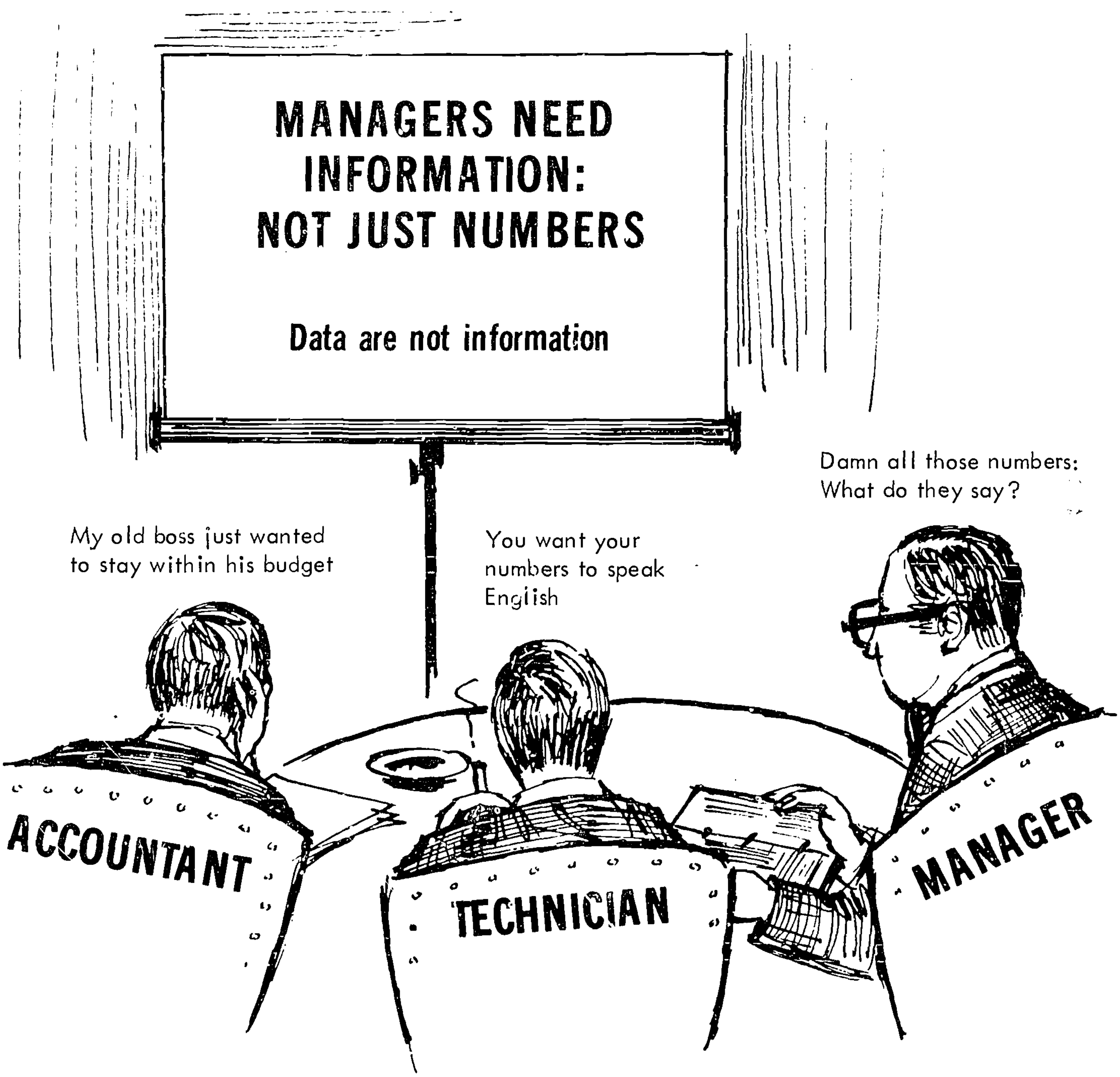
PART I
THE NEED FOR ANALYSIS

I – 1


MANAGERS NEED
INFORMATION:
NOT JUST NUMBERS
Data are not information
My old boss just wanted
to stay within his budget
You want your
numbers to speak
English
Damn all those numbers:
What do they say?
ACCOUNTANT
TECHNICIAN
MANAGER

1. Managers Need Information—Not Just Numbers

This book is about numbers—specifically those which relate accomplishments to their costs. It explains how managers can use cost and output data to obtain information which will help them make better use of resources—people and things. If you have management responsibilities at any level, and if your activity is one for which cost and output data are being or can be collected, these pages are directed to you. They will explain how the right numbers, properly used, can help you make better decisions in your job as manager.

Analysis begins with a record keeping system which supplies adequate cost and output data for your activity. But simply collecting *numbers* is not analysis. First, they must be the right numbers. You must be able to identify quantitatively what got done over a specific period of time (accomplishment or output) and to match this with the resources consumed (costs) over the same period of time. The costs must include *all* those resources and *only* those resources used in turning out this output; and the product or service must be *all* the output but *only* the output associated with those costs. Furthermore, many analytic uses require numbers which are comparable *over time* and *over a considerable range of outputs.*

Even when cost and output data meet these requirements, they do not—in themselves—help managers of operating activities make better decisions. *Data are not information.* They do not become information until they are organized in such a way that you can make *comparisons* (between planned output and actual output, for instance, or between two facilities engaged in similar work) and can *identify relationships*, such as that between costs and output over a range of operating levels.

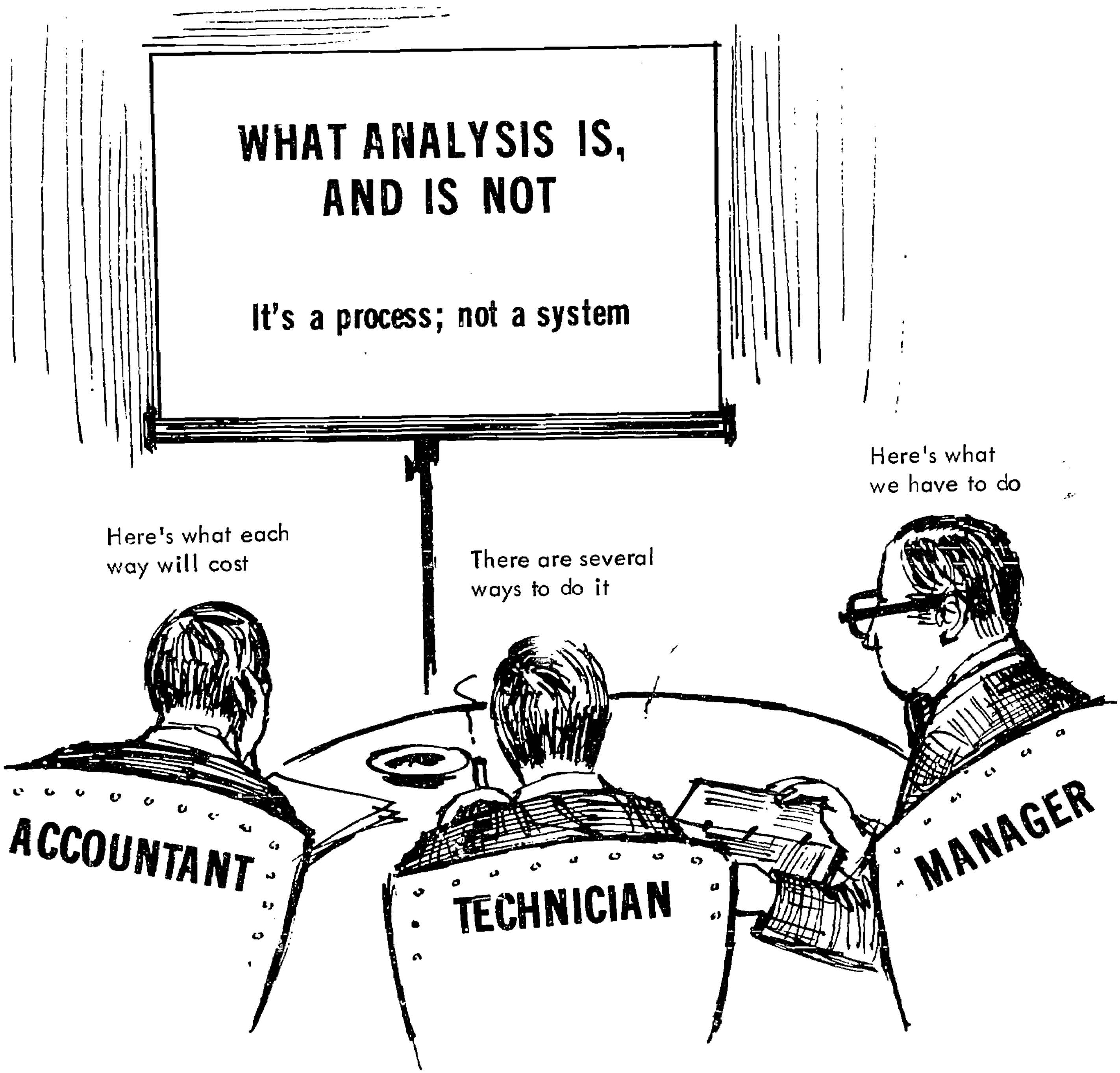
This book is about those comparisons and relationships. It shows—with examples—how significant information can be developed from appropriate data and how that information can be useful to managers in a broad range of situations which call for operating decisions. It is concerned with some of the conceptual problems faced in collecting and interpreting cost and output data—particularly by managers in government activities. It is concerned also with recognizing the limitations of available data—and the uses to which imperfect numbers can and cannot be put.

It does not set out to teach the specific statistical techniques that may be applied in developing information from numbers. Much of the analysis described in the pages which follow will not require a formal application of statistical procedures. And where it does, many managers—particularly those at installations with computer facilities—will call on a statistician. If you choose to work directly with the numbers yourself, any standard statistical text will detail the techniques which are not hard to learn.

Whatever cost and output numbers are now being collected for your activity, reading this book may have three results. First, you will find ways in which you can use at least some of the available numbers to help solve management problems. Next, you are likely to learn that numbers currently being collected are inadequate or misleading in ways that make them less useful than they might be. For instance, data on operating costs may not be matched with equally reliable data on what got done over the same period of time, or cost figures may include items that are not relevant to your management decisions. You may well find that rather simple changes in record keeping procedures could make the numbers much more useful analytically. In any event, you will learn the kinds of analysis for which your numbers are suitable and the kinds for which they are *not*. And when you understand these limitations you will be able to protect yourself against the *misuse* of these numbers by others. And finally, you may uncover some numbers which are neither used nor useful and should no longer be collected.

If none of these possibilities intrigue you, you need not read further: this book is not for you. But if they do, the purpose of the following pages is to explain how numbers—specifically, cost and output data—appropriately arranged and analyzed, can lead to better use of resources—people and things.

I –2


WHAT ANALYSIS IS, AND IS NOT
It's a process; not a system
Here's what each way will cost
There are several ways to do it
Here's what we have to do
ACCOUNTANT
TECHNICIAN
MANAGER

2. What Analysis Is, and Is Not

The essential ingredients of management decisions are people and things. Managers in all kinds of jobs, whether business or government, civilian or defense, and at all levels, have to make decisions about the best ways of combining people (clerks, production workers, technicians or scientists) and things (office supplies, machinery, sacks of flour, or missile systems) to turn out whatever happens to be the end product of *their* activity. They must make such decisions whether that product is something as tangible as engines repaired or as elusive as the capability of a weapons system, and in order to make the best possible decisions, they utilize whatever evidence is available to them.

In every day language, analysis is simply a rational way of approaching problems which require decisions. All of us engage in analysis; we try to find out what went wrong with a golf stroke or why the car is making unfamiliar noises. In the case of management decisions, analysis is concerned with choices: alternative ways of acquiring and using resources (people and things) in various combinations to accomplish various objectives.

Many of these choices—particularly for ongoing activities with a readily definable output—involve changes up or down from existing levels of production or expenditure. We start from where we are and consider the impact of a change from that starting point: most obviously, of course, changes in next year's budget or workload, but also such other changes as those in specifications for the job to be done, in service or quality of an end product, in wage rates or the cost of supplies, in the way work is distributed among two or more installations, in *any* factor likely to have an impact on the activity's cost or output. Since decisions at the operating level are of this type, the focus of this book will be directed primarily toward analysis dealing with problems in this category.

There are other highly important but less frequent decisions which involve major acquisitions. These may range from a choice at the highest level among alternative weapons systems through the pros and cons of building a new hospital or undertaking the major remodeling of an old one to selection of new equipment at an office-management level. Such decisions also rest on a comparison of the relative costs and benefits of each alternative being considered, though the information supplied by record systems based on operating experience often does not furnish direct precedents for making these comparisons, necessitating use of various estimating procedures.

As practiced in the Department of Defense, economic analysis has tended to concentrate on large scale procurement programs and projects. For decisions of this sort, preparation of a formal analysis is required, and for these situations a detailed procedure has been prescribed. (See *Economic Analysis Handbook* prepared by Defense Economic Analysis Council, Department of Defense.) Indeed, the term "economic analysis" is sometimes reserved specifically to describe this process of choosing among major investment alternatives, while the range of decisions which involve changes in an ongoing activity may be labelled "program evaluation" i.e. ways to improve existing operations. No such distinction is made here since analytic techniques can be applied to any problem for which you find them useful and at any level of decision making.

The tendency for policy makers to focus on large scale procurement projects rather than operating level decisions is understandable. When a single decision involves many millions of dollars, the potential savings from making a better decision will be dramatically large. In other areas, the spending of Operation and Maintenance funds, for instance, individual management decisions are unlikely to produce such dramatic results. But collectively, the potential savings are fully as great.

The Operation and Maintenance budget constitutes about 25 percent of the Department of Defense's total budget authority—$23.1 billion proposed for Fiscal Year 1974 as compared with an $18.8 billion total for Procurement. Among the major programs itemized in the Department of Defense Financial Summary, support activities such as Training, Medical, Other General Personnel Activities call for $18.2 billion; Central Supply and Maintenance for $8.4 billion; Intelligence and Communication, $6' billion; Airlift and Sealift, $0.8 billion; Administration and Associated Activities, $1.7 billion. In each of these areas, a generalized improvement in management decisions could produce huge savings.

The cost of operating a military food service center may involve a relatively modest $100,000 annually, but food services cost the Department of Defense over $3 billion each year. Motor pools, hospitals, basic training facilities, and the like, all provide similar examples. Each is a relatively small operation, but collectively such routine ongoing activities become the *largest resource user* the Department has. Moreover, because many of these activities lend themselves to cost and output measurement, analysis can contribute more easily to such improvement.

As this book will demonstrate, analysis, at its lowest level, may consist simply of collecting the right numbers and organizing them to display information useful to you as a manager. Most often, analysis will involve using simple arithmetic with a pencil and ruler to obtain *more information* from your data and, if time permits, of applying elementary statistics to make that information *more precise*.

These various uses of cost and output numbers will be presented and explained in Part II. Section 1 of that Part demonstrates the value of data formats which highlight directly the relationship of actual to planned output and actual to planned costs and display trends in those relationships over time. Section 2 shows how data collected over a range of output levels can be used to establish the relationship of operating costs to different *levels* of output and illustrates ways in which knowledge of this relationship can be used.

Sections 3 and 4 are concerned with problems—conceptual and practical—in measuring cost and output to obtain data which will be useful for analysis.

Section 5 deals with the use of cost and output data to select the least costly way of combining resources (people and things) to achieve a particular level of output and also ways of identifying the most efficient *scale* for facilities which provide a particular end product or service.

As a practical matter, actual cost and output numbers collected by an operating activity will always be imperfect. Section 6 considers the use of such data—what adjustments can or must be made to make comparisons valid and what statistical techniques can make it possible to identify significant relationships even when working with imprecise data.

With this background, Section 7 returns to the problems of data collection—of making sure that record keeping systems supply cost and output numbers appropriate for alalysis. It summarizes, in the form of a check list, the most significant criteria for such systems.

Finally, in Part III, the techniques discussed in Part II are applied to real instead of hypothetical cost and output data collected by *actual* operating activities. These case histories illustrate the use of analysis in several situations which required management decisions.

The importance of cost and output information of the sort described in these pages extends beyond the operating level where the numbers are collected. Both the numbers and the management decisions made at that level become an integral part of the decision making process at successively higher levels. Cost and output numbers—organized so as to display useful information—become part of the data that top level managers and analysts consider in estimating the costs and benefits which can be expected from the various defense options open to them. Moreover, these top level decision makers need to be confident that their estimates represent the lowest possible costs associated with each alternative under consideration. And each component in those estimates represents *output*—an end product at some level.

Analysis should not be an occasional major undertaking but a way of life—a continuing *process* in which you, as a manager, can obtain information from numbers and apply that information as an aid to judgment. Analysis can be helpful at all levels of decision-making from improving day-to-day operations to long range planning, programming and budgeting.

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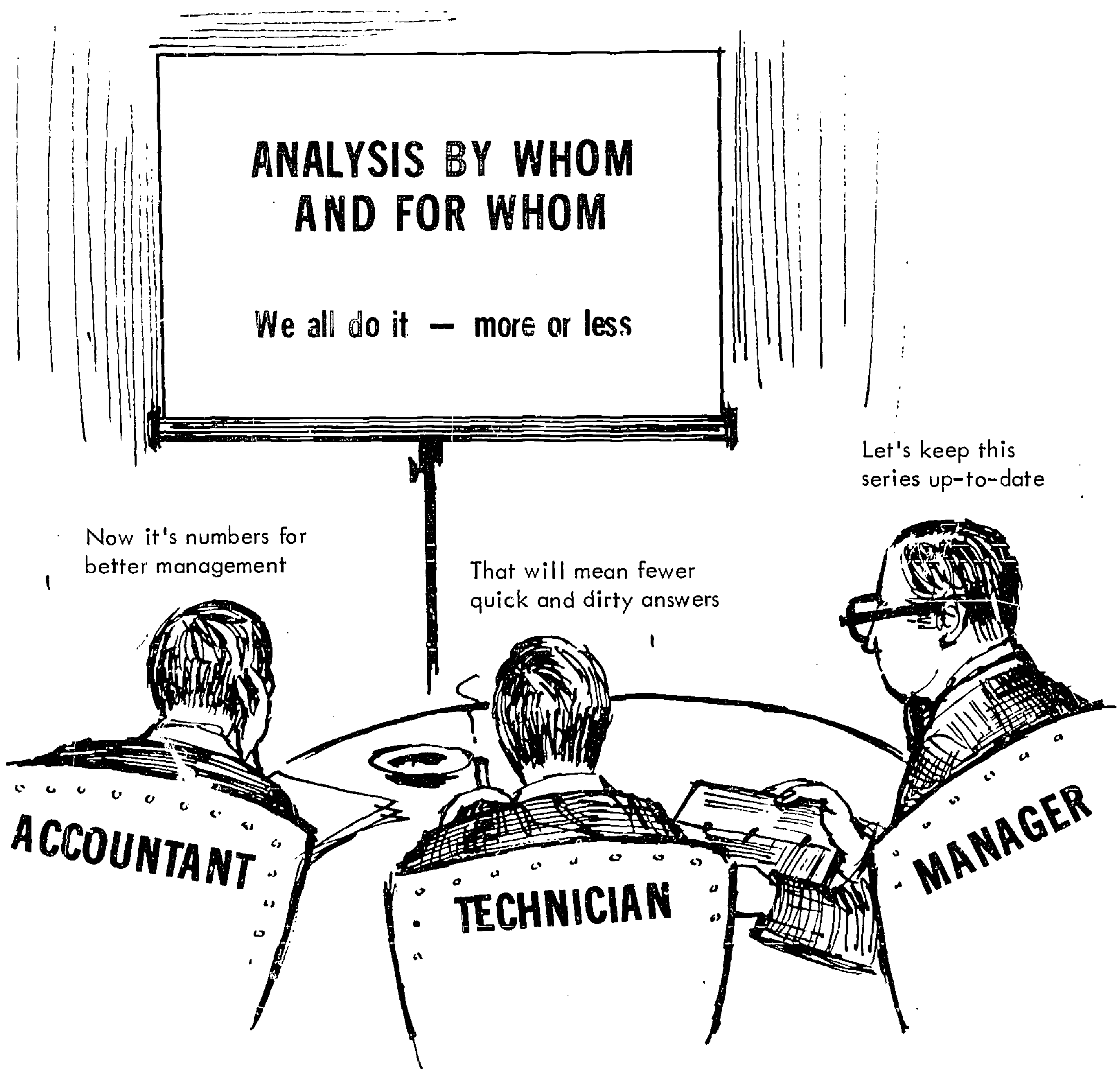
ANALYSIS BY WHOM
AND FOR WHOM
We all do it — more or less
Now it's numbers for better management
That will mean fewer quick and dirty answers
Let's keep this series up-to-date
ACCOUNTANT
TECHNICIAN
MANAGER

3. Analysis by Whom and for Whom

The heading at the top of this page reflects a conventional way of looking at analysis as something that someone (the analyst) does to data. His activity is supposed to yield suggested conclusions (analysis). These can then be turned over to someone else (the user) who will, hopefully, find them helpful in arriving at some (unspecified) management decision.

If you have read this far, you already realize that this view is partial and seriously misleading. Analysis is not an act performed by a technical specialist called an analyst; it is a *process* of using numbers to improve decision making. It includes several stages which take place over time and call for active participation by the resource manager, the statistical analyst and everyone involved in collecting, verifying and organizing the data on which the analysis is based.

If the end product is to be helpful in solving a management problem, analysis must *begin* with a clear formulation of the problem for which a solution is sought. Only the decision maker himself (in conventional terms the "user" of the completed analysis) can provide this perspective.

The problem may be a continuing one such as performance evaluation; it may be recurrent like the need to prepare budget estimates which take account of prospective changes in workload, responsibilities or performance standards; it may pose specific choices: where to allocate additional work among two or more facilities (or where to cut back); whether to expand (or consolidate) existing facilities, set up new ones, decentralize or shut down old ones; whether to acquire more highly automated equipment, hire additional workers, or rely on some combination of the two.

As a broad generalization, the contribution of quantitative analysis to solving any of these problems lies in identifying the relationship between cost and output under varying conditions and providing comparisons. These may include comparisons over time, comparisons among two or more facilities, comparisons over a range of operating levels or among facilities of differing size, comparisons of operations carried out with differing combinations of resources (people and equipment). Part II will describe in some detail ways of making a number of these comparisons, and a technical specialist (the analyst) can apply any statistical techniques which are required. But the manager must decide which comparisons will be relevant and helpful in solving his particular problem.

Similarly, an analyst can tell him what numbers are needed to apply the analytic techniques they select, but the manager must know what data are currently being collected for his operation, decide whether additional numbers should be obtained, and work with those involved in collecting and processing data to set up new or modified record keeping procedures where these are needed.

Even more important, he must *understand* the data—what goes into the cost figures he receives, how output is measured, what time spans are covered by cost and output figures respectively, changes over time which affect the comparability of supposedly similar items. Such factors may preclude using certain data for some purposes and in any case will affect his interpretation of the results.

Once the procedures for acquiring and analyzing suitable data have been set up, it will often be possible to continue them routinely at a clerical level and to program many of the statistical operations for computer processing. The manager will then be able to turn more of his attention to interpreting the results. But no matter how carefully designed an information system may be, he should never accept a continuing flow of numbers without scrutiny. A computer may be programmed to flag variations in data or statistical ratios which exceed some predetermined limit, but it cannot explain why such variations occur.

Someone familiar with the actual conditions under which a facility or agency operates will have to decide whether particular changes affect the validity of key comparisons—those made over time, for instance, or among different installations. The "user" of analysis must play a continuing role in identifying such changes and in seeing that appropriate adjustments are made either in the statistics themselves or in the way he interprets them. This is part of the decision maker's responsibility for exercising judgment.

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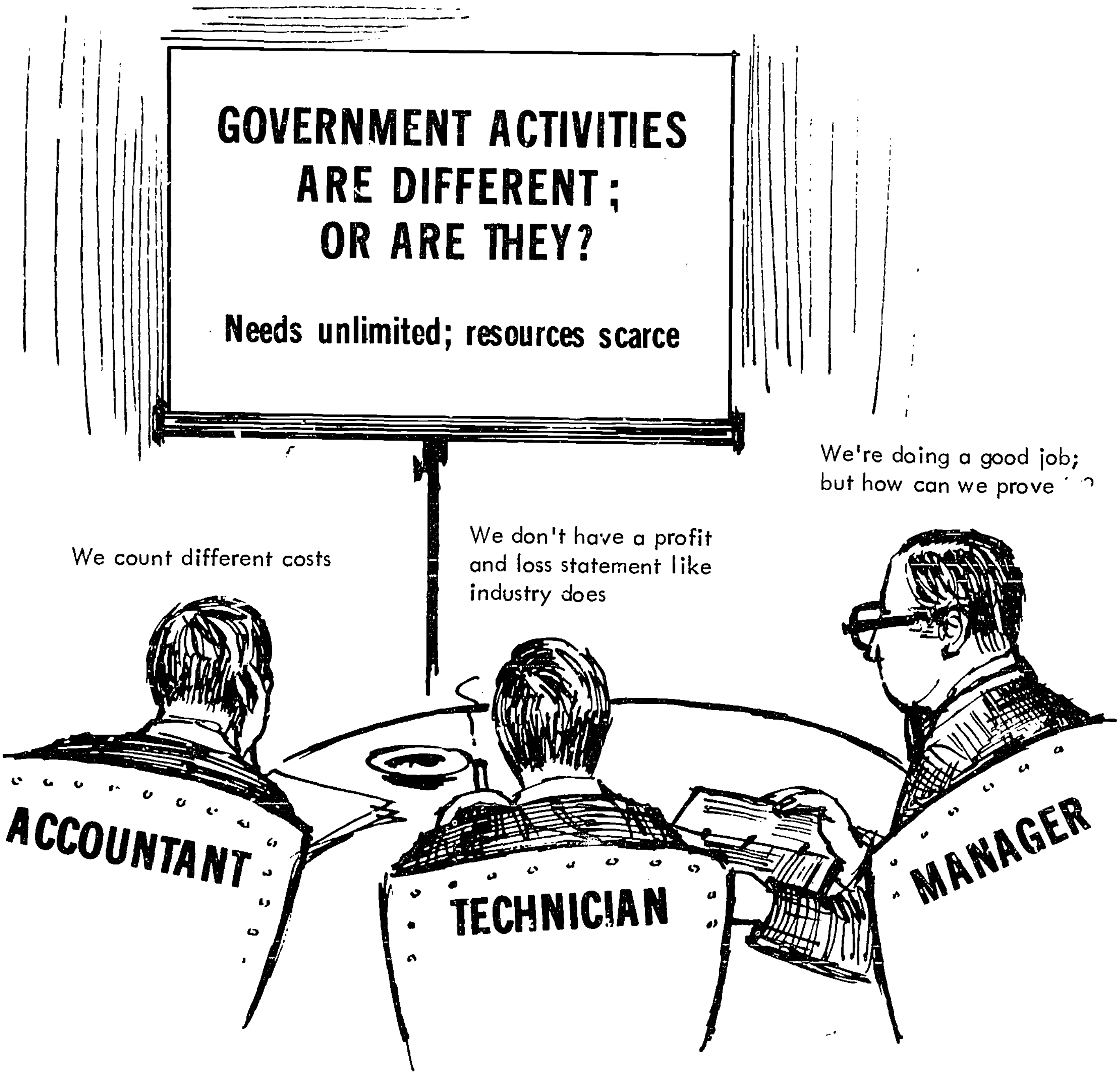

GOVERNMENT ACTIVITIES
ARE DIFFERENT;
OR ARE THEY?
Needs unlimited; resources scarce
We count different costs
We don't have a profit and loss statement like industry does
We're doing a good job; but how can we prove
ACCOUNTANT
TECHNICIAN
MANAGER

4. Government Activities Are Different—Or Are They?

Whether managers of operating activities work for government or business, they need the same types of information in deciding how to make the best use of resources. The same cost/output relationships are significant to both. In this basic sense, government activities are not different from business.

But you, as a maker of management decisions at some level within a government agency, face special problems in obtaining good cost and output data which your opposite number in industry may take for granted. On the other hand, you are likely to find that having the *right* numbers and being able to present them convincingly is even more important to you—especially in estimating and justifying your budget needs—than it is for your counterpart in the private economy.

Government activities face specific challenges in measuring both cost and output. On the cost side, these arise from record keeping procedures and particularly from the *time* at which expenditures have traditionally been recorded. Output measurement, on the other hand, poses problems because of the way in which services performed by government are customarily provided to the public.

Traditionally, government activities have kept detailed records of costs, principally to make sure that obligations to spend money do not exceed authorizations to obligate and that expenditures do not exceed what has been budgeted. Departmental officials—and the Congress—have needed, and always *will* need, records for purposes of control. The traditional records perform this essential function of holding commitments and expenditures within specified limits; they keep resource managers accurate and honest, but that is all they do; and that is no longer enough.

Resources (people or things) are not consumed at the time they are ordered, or at the time they are delivered, or at the time they are paid for. Consequently, cost records geared to orders placed, deliveries received, or disbursements made cannot be matched, timewise, with the particular output for which those resources were actually *used*. Traditional government accounting records have not supplied the numbers needed to do this.

Managers in private business on the other hand *can* obtain the numbers they need from their accounting records. Since business offers its output—goods or services—for sale in the market, managers must know whether the selling prices of specific items cover, exceed, or fall short of their cost (that is, the resources consumed in producing them). To associate specific costs with specific output, resources are treated as "costs," not when they are ordered, delivered, or paid for, but when they are *used*. *Accrual accounting*, as this method of record keeping is called, allows business managers to measure the resources consumed during a specified period of time and match them with results (sales) during the same period.

Similarly, business managers need to match each price on their sales list with the cost of turning out the particular item to which it applies. This requirement has given business accountants an incentive to distinguish those cost elements which are relevant to particular types of output and to allocate joint expenditures among their several end products.

Historically, the records kept for *governmental* operations, detailed as they have been in other respects, have not filled either of these needs. This gap in information was recognized in the 1966 Department of Defense Instruction (DoD I 7000.1) which required establishment of Resource Management Systems for a variety of operations within the Department. In recent years much attention has been focused on collecting cost data in a form which does permit direct cost/output comparisons. For many operations, numbers suitable for at least some such comparisons are becoming available.

But cost data provide only half of the numbers needed for cost/output comparisons. Such comparisons cannot be made unless you are also able to measure what got done during the same time period. Both business and government use resources in order to fill "needs"—that is, they turn out products or services that people want. But output measurement is more difficult for government activities because most government services, instead of being sold in the market, are furnished directly to the public and paid for out of government funds. The manager of a business which offers its product for sale has an immediate measure of output in sales and associated revenues. As the table below shows, the resultant figure on profit or loss even gives him a first approximation to measuring his performance:

	BUSINESS	GOVERNMENT
• Measure of what got done	Sales (Revenues)	Output
• Cost of what got done	Cost	Cost
• Measure of performance	Profit (Loss)	Needs met

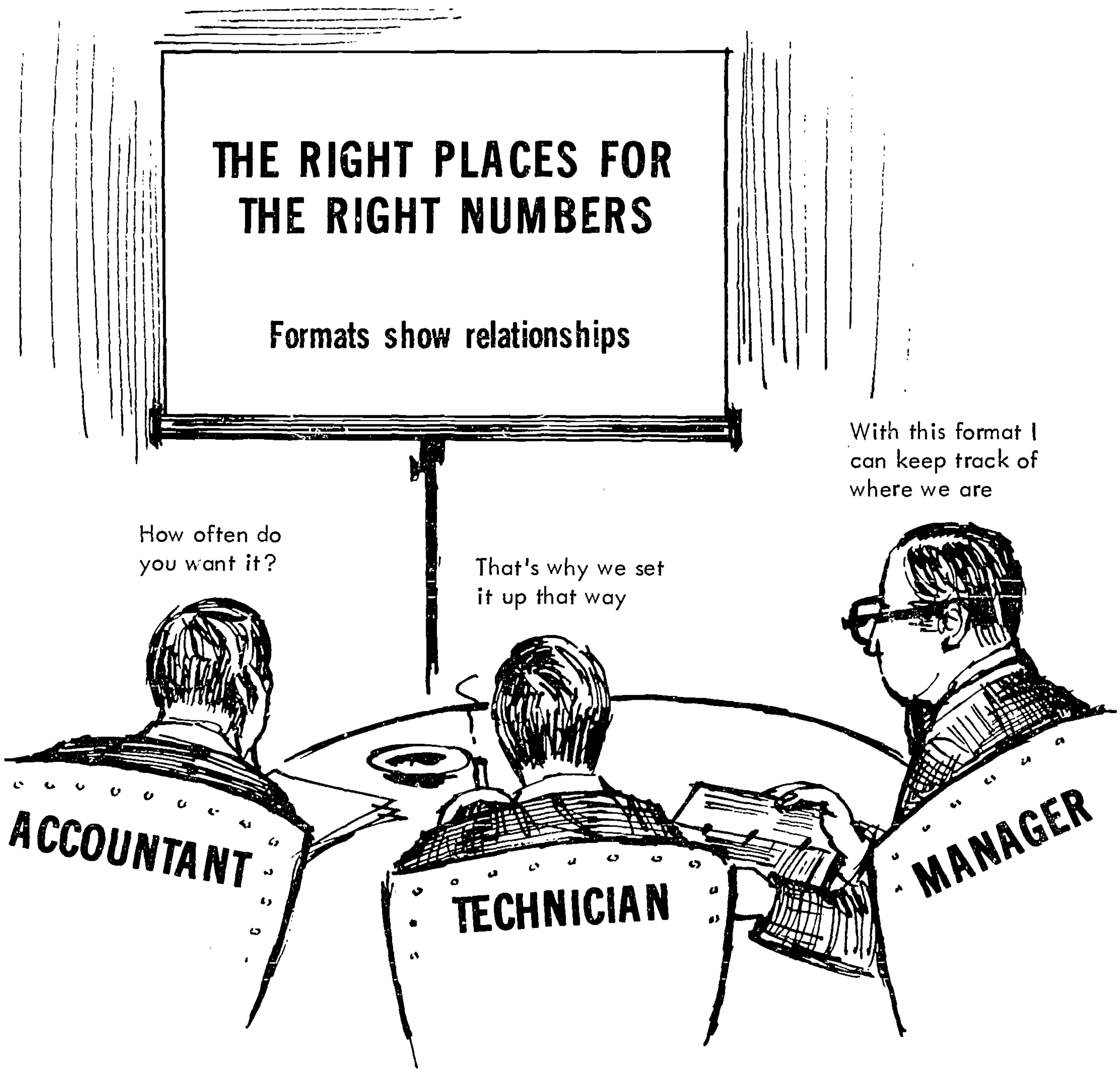
Moreover, these "measures" which are generated by business through the very process of doing business are expressed in a common denominator: dollars. The dollar amounts can be related directly to cost data; they can also be compared with sales and revenues for a range of price lines (similar items made to different quality specifications), and they can even be compared with amounts the buying public chooses to spend on the output of other, quite different business activities.

The market does not provide the manager of a government activity with these direct dollar comparisons. For equivalent information on physical output units, he must look to a records *system* instead of sales records. He will not find any equivalent for the market's direct indication of *dollar value*. When tax money is spent to meet a public need, the public cannot record its satisfaction or dissatisfaction directly by generating profits or losses. Instead, the value of any government activity's proposed output—relative to other uses for the same money—is judged at successively higher levels of *budget review*.

This is a process which culminates in Congressional decisions to commence, to continue, to increase, or to cut current appropriations. And at every level of review, an activity's budget will be in jeopardy if its managers cannot show, quantitatively, what has been accomplished for past expenditures *and* what can be expected from expenditures proposed for the future.

PART II
SOME TECHNIQUES OF ANALYSIS

II – 1


THE RIGHT PLACES FOR
THE RIGHT NUMBERS
Formats show relationships
With this format I can keep track of where we are
How often do you want it?
That's why we set it up that way
ACCOUNTANT
TECHNICIAN
MANAGER

1. The Right Places for the Right Numbers

Data are not information; they *become* information only when you, the *user*, are able to make comparisons or identify relationships which are significant in managing your activity. Even the most accurate cost and output numbers will not—by themselves—tell you how this month's performance compares with last month's or how actual accomplishment matches what you (and others) were expecting.

Data *become* information when they are so arranged that you can make these comparisons, or others which are relevant to your current problems. The arrangement need not involve statistical techniques. It may involve nothing more than finding the right places for numbers that are already being collected regularly.

Suppose output data are available and you are interested in comparing your activity's performance this month with last month and the month before that. You might set down the monthly figure side by side:

Table 1

	Month Before Last	Last Month	This Month	Next Month
Output	90	95	100	

Comments:

This tells you that actual output has increased each month over the three month period—a fact of some significance. But it does not tell you in a truly meaningful way that this month was "better" than last month and the month before.

By providing a data format with additional slots to display each month's planned results alongside actual output, the amount of information immediately increases. Suppose, for instance that a constant level of output, say 100 units, had been expected each month. (See Table 2). From the numbers in this display, you see not only that output increased each month but also that actual performance, originally below expectations, first approached and then reached the planned level.

On the other hand, displaying these same actual outputs alongside planned amounts might

Table 2

	Month Before Last	Last Month	This Month	Next Month
Planned Output	100	100	100	100
Actual Output	90	95	100	
Difference	−10	−5	0	
% Actual of Planned	90	95	100	

Comments:

have revealed that the monthly increases did not in fact represent improved performance. Suppose the figures for planned output had called for substantial increases in the amount of work to be turned out each month:

Table 3

	Month Before Last	Last Month	This Month	Next Month
Planned Output	100	110	120	130
Actual Output	90	95	100	
Difference	−10	−15	−20	
% Actual of Planned	90	86	83	

Comments:

Although the monthly rise in output is identical with that recorded in Table 2, Table 3 would reveal at a glance that your activity, far from improving its performance during the three month period, was really falling farther and farther behind its target: only 83 percent of expectations this month, whereas comparable percentages for the two previous months had been 90 and 86 percent respectively.

Output data can yield this information without any application of statistical techniques, simply through arranging the numbers to display directly comparisons *over time* and of *planned results with actual*. These comparisons constitute an elementary but exceedingly valuable type of analysis.

Still more revealing is the information that becomes available when *both cost and output data* for the same activity are arranged in identical formats and set side by side. Suppose cost and output numbers for your activity over the last three months were as follows:

Table 4a
COST
(Thousands of dollars)

	Month Before Last	Last Month	This Month	Next Month
Planned (Cumulative)	100 (100)	100 (200)	100 (300)	
Actual (Cumulative)	100 (100)	100 (200)	100 (300)	
Difference	0	0	0	
% Actual of Planned	100	100	100	

Comments:

Table 4b
OUTPUT
(Number of end products)

	Month Before Last	Last Month	This Month	Next Month
Planned (Cumulative)	100 (100)	100 (200)	100 (300)	
Actual (Cumulative)	100 (100)	95 (195)	90 (285)	
Difference	0	-5	-10	
% Actual of Planned	100	95	90	

Comments:

Examining the cost record by itself, you would conclude that operations were proceeding according to plan—for each month, expenses actually incurred were equal to those expected for that time period. But the record for output tells a different story; actual end products matched expectations only in the first month, then fell short by increasing amounts. The comparison becomes even more unfavorable when the two sets of data are considered side by side, since output fell below expectations by increasing amounts while these monthly reductions were *not* matched by any corresponding reduction in costs. Here is a situation which you, as a manager, would clearly wish to know about promptly. Conversely, of course, unplanned deviations in expenditures might alert you to the need for investigating a situation in which output has appeared to be consistently on target.

An adequate data format should display both cost and output figures; either record, by itself, may be highly misleading. This requirement is significant because data on an activity's costs are more often already being collected, more complete or easier to obtain than comparable figures on output. In many situations where output is difficult to measure, cost data are used as indicators of accomplishment.

For some purposes, such an indicator may be useful—or at least "better than nothing." But for many types of analysis, it is more likely to be "worse than nothing." When you use cost data to keep track of accomplishment, you are assuming that every change in the amount of resources used by your activity results in an exactly proportional change in the work turned out. For most kinds of work, this assumption is not warranted. Not only are the changes often likely to be disproportionate, but such divergences are themselves extremely significant information for supervisors, managers, budget officers and all those concerned with longer range planning. Much of a manager's job consists of understanding when and why disproportionate variations occur and deciding what—if anything—should be done about them.

This is the reason why, in most government activities, increasing emphasis is now being placed on measuring output directly rather than relying on cost records as an indirect indicator of accomplishment. If yours is an on-going activity with a readily recognizable end product, statistics are very likely being collected on the number of objects turned out or services performed over given time periods: meals served, engines reworked, recruits trained, forms processed or whatever. There are problems and pitfalls in collecting such numbers, some of which will be discussed in more detail in Section 4 of this Part. These problems become more difficult for activities with complex end products or missions which are not readily countable.

Finding ways to measure output statistically is well worth the effort; much of the analysis described later depends on establishing mathematical relationships between costs and output over a range of outputs. But even if such numbers are not yet available for your activity, you can use the technique described above for monitoring performance over time. As explained here, this involves making two *independent* sets of comparisons for the same time period—one between actual costs and planned costs, the other between actual accomplishments and planned accomplishments—and then matching the two trends to discover whether they parallel each other or diverge. Even an array of plans in the form of a written list with items crossed off as they are accomplished could furnish some basis for this comparison. The essential requirement is to keep the method for assessing accomplishment independent of cost records so that the two trends can legitimately be compared with each other.

Since the purpose of such comparisons is to alert you—as manager—whenever actual operations diverge from expectations, developing trends may become apparent more quickly if you can see the numbers transformed into lines on a chart.

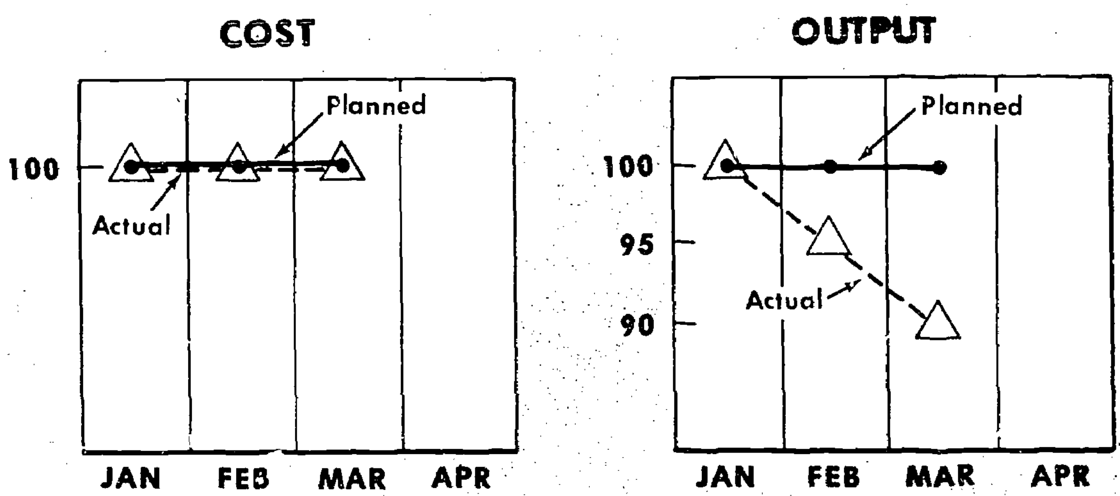
Consider the figures for cost and output from Table 4 above. These could be plotted in several ways. One way is to plot actual numbers against planned numbers. (See Figure 1.)

A glance at the two charts quickly indicates that actual costs have matched planned costs exactly but that output, over the same time span, has been falling farther and farther below expectations.

These facts might also be combined in a single chart by showing the percentage relationship of actual cost to expected cost for each month as one line and the relationship of actual to expected output as the other. In this chart the divergence between *trends* for cost and output data is highlighted even more directly. Figure 2.)

If an activity's level of operations often fluctuates considerably from month to month, another graphic technique is likely to be useful. It involves plotting the cumulative totals for each month and the preceeding months, revealing at a glance whether monthly departures from expected norms have tended to build up over time or to cancel out. Using the data presented in the same table (Table 4), for instance, the cumulative impact of the downtrend in output relative to expectations is immediately apparent. (Figure 3.)

Figure 1

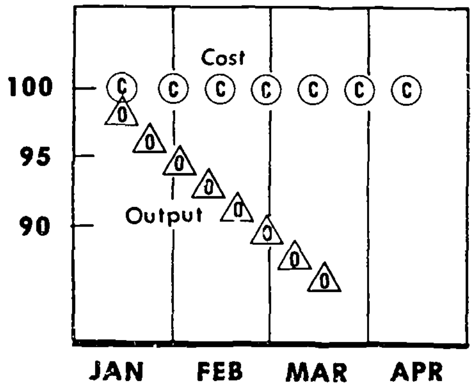


Comments:

Comments:

Figure 2

Percent Actual of Planned



Comments:

Another type of graphic presentation likely to be useful in an activity where the workload fluctuates around the norm from month to month can relieve managers of much routine supervision. This technique, sometimes referred to as "management by exception," can be used when the supervisor knows, from experience, the approximate range—say 10% above or below the planned level—within which monthly results can normally be expected to fluctuate.

Suppose this is the case in your activity and that, over a three month period, the ratios of actual to planned output and of actual to planned costs have varied as shown below:

Table 5

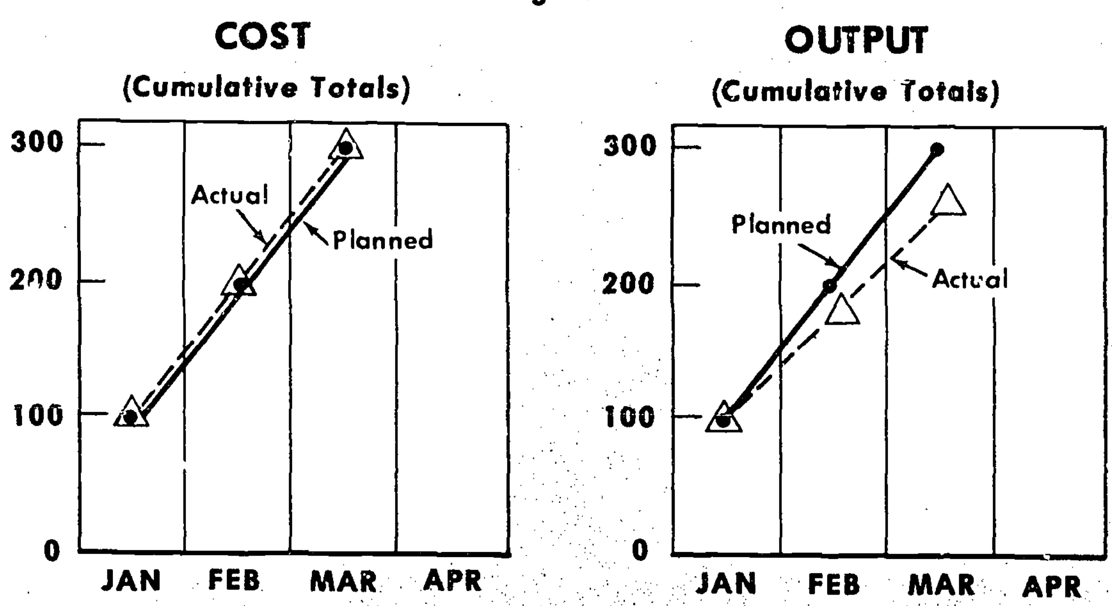
		Month Before Last	Last Month	This Month
Cost	Planned Cost	100	120	110
	Actual Cost	95	125	130
	Ratio-Actual/ Planned	95	104	118

Comments:

Output	Planned Output	100	120	110
	Actual Output	90	130	85
	Ratio-Actual/ Planned	90	108	78

Comments:

Figure 3

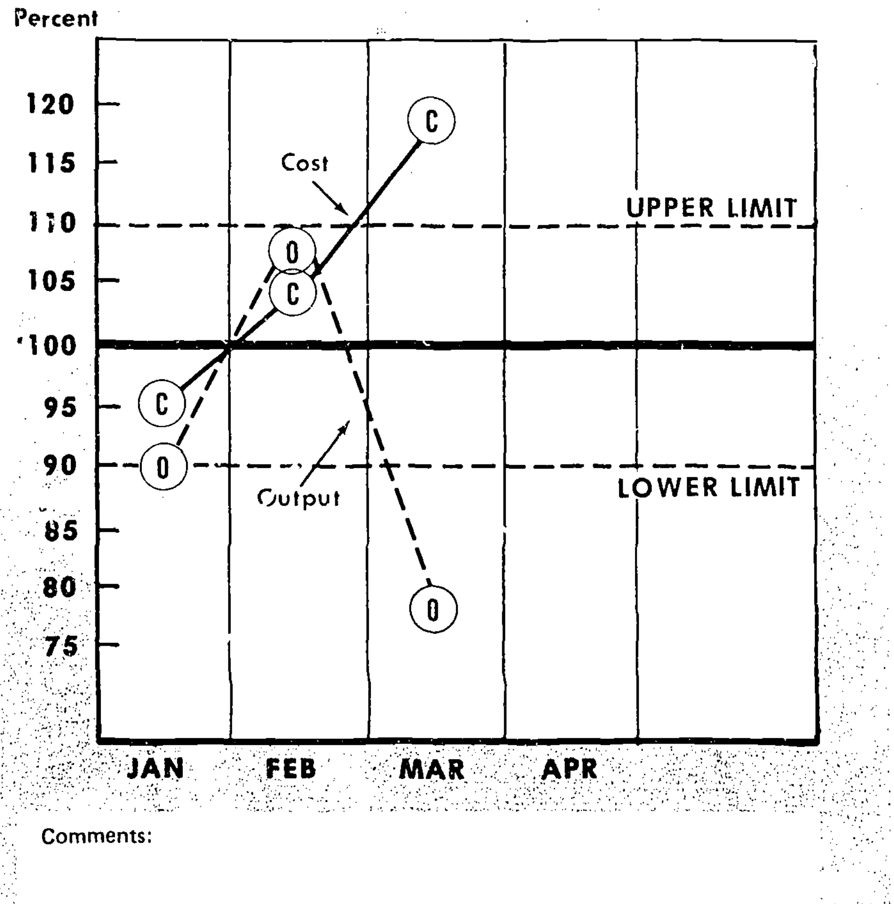


Using these numbers, monthly actual-to-planned ratios for both cost and output can be plotted above and below a centerline (actual equals 100 percent planned), showing each month's percentage deviation from expected costs and output. (See Figure 4.) The two broken lines on the chart mark off deviations of 10 percent above and below expectations. On the basis of experience, these form a band of allowable variations. When a monthly deviation from planned performance falls outside this range, the chart alerts the manager to the need for more than routine supervision. As plotted above, deviations flagged in the third month would require investigation and possible corrective action.

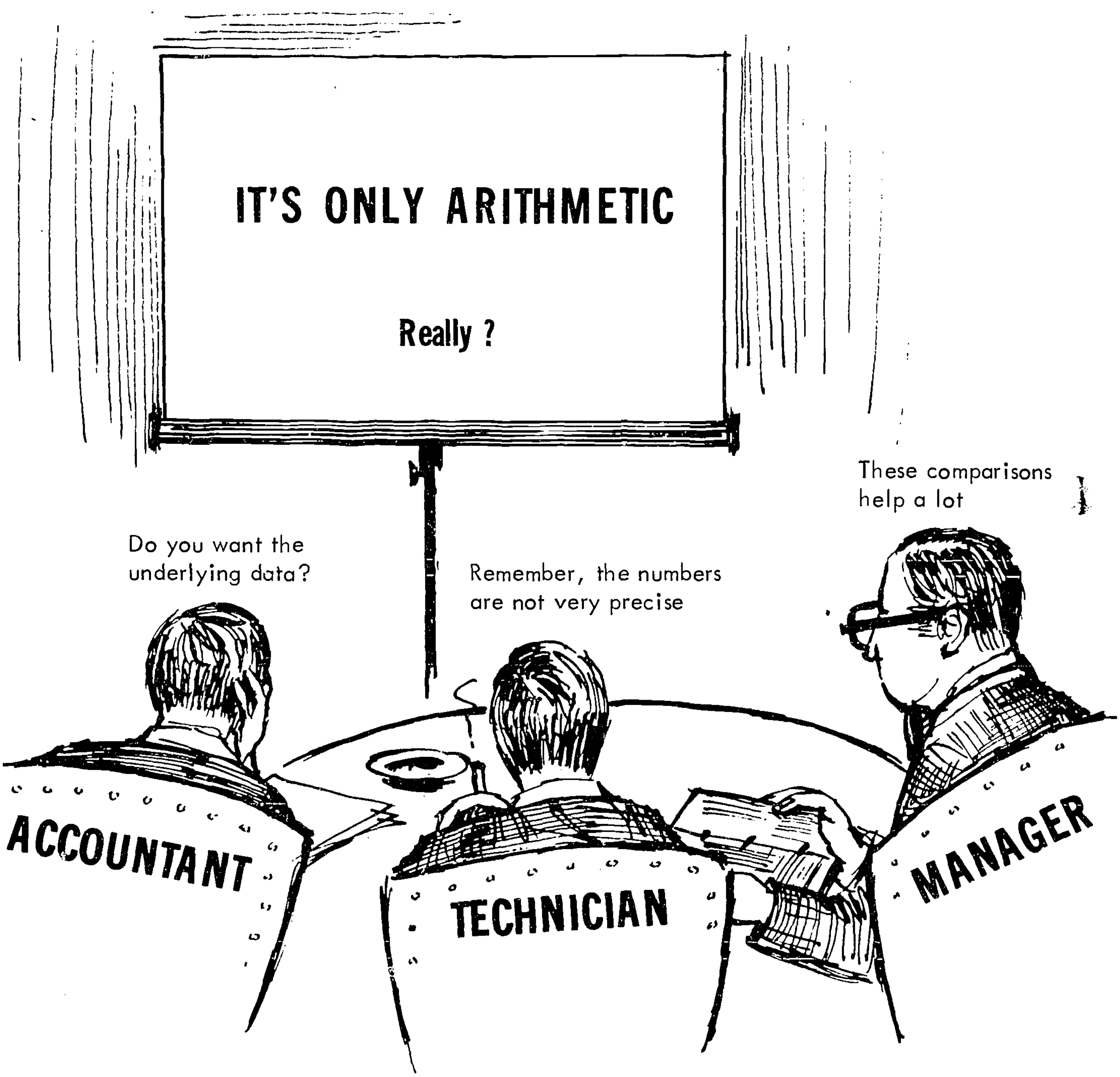
The choice of specific limits in such a chart is, of course, a product of judgment as well as experience. To tighten control, the permissible deviation limits may be narrowed; unnecessarily rigid controls, on the other hand, may be relaxed by widening the range within which variations will not be treated as "out of line." The technique provides a basis for better control over an activity and can, at the same time, relieve the manager of routine work. This is an example of cost and output numbers used, as they should be, to aid experience rather than to replace it.

Figure 4

Ratio of Actual to Planned



II – 2

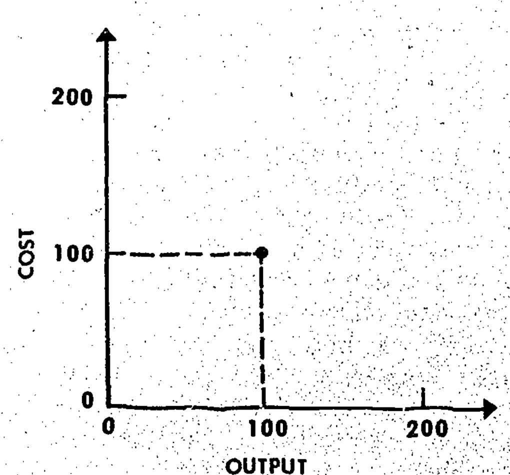

IT'S ONLY ARITHMETIC
Really ?
Do you want the underlying data?
Remember, the numbers are not very precise
These comparisons help a lot
ACCOUNTANT
TECHNICIAN
MANAGER

2. It's Only Arithmetic

Keeping good cost and output records for an operating activity could pay its way in more efficient management even if the numbers were used only for monitoring current operations as described in the preceeding section. But they can do much more. Over time they will provide the data base needed for relating costs to output and for doing so *over a range of outputs.* This section and most of those which follow will deal with techniques for analyzing that relationship and drawing conclusions which are significant for a wide variety of management decisions.

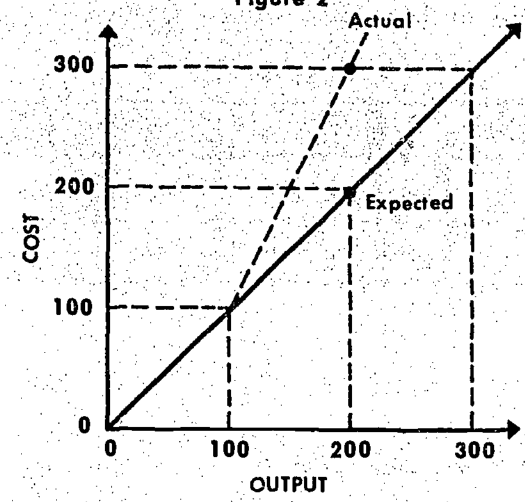
If you are sure that cost and output numbers for a particular month really match, timewise and otherwise (a requirement which will be explained in detail in Section 3), these two numbers can be related graphically. The graph will show output—measured in physical units—along the horizontal axis while cost—measured in dollars—is plotted along the vertical axis. For instance, if your activity turned out 100 units of output and used $100 worth of resources in doing so, both cost and output observations would appear as a single point on this graph:

Figure 1



Barring a future change in circumstances, that point gives you a fix on what it costs to turn out 100 units of output over the space of a month; this is the *only* information it supplies. It does not tell you what total costs would be if your activity's workload changed sharply—doubled or tripled or was cut in half. But the graph provides a means of visualizing your *expectations* about what would happen to costs as output rose or fell. If, for instance, you were to assume that the change in costs would be proportional—that your facility, with its present capacity, could cope with a doubled workload by doubling current expenditures—additional points could be plotted to reflect this expected cost/output relationship and joined by a *solid* line like that in Figure 2:

Figure 2



Suppose your activity were then required, in fact, to turn out a larger amount of work, say 200 units. The cost/output point associated with that actual peak load might or might not lie along the *expected* cost/output line. If the actual observation was above the line (as shown by the dotted line in Figure 2) it would show that the cost increases associated with increases in output exceeded expectations. In this example when output was pushed from 100 to 200, costs were expected to rise to $200 on the vertical axis; but in fact they rose to $300.

This divergence of actual from expected costs *might* be interpreted as were the deviations discussed in the last section: that is, it might suggest possible operating problems to be investigated. On the other hand, it *might* indicate that your expectations had been unrealistic.

Analysis can help determine whether or not cost/output relationships—for *this* particular activity and over this range of outputs—are what you have assumed.

In order to predict how much impact a proposed change in your activity's output will have on costs, cost/output observations must be available for each of several *different* levels of output. These may be drawn from the activity's own records over time or they may be data for similar facilities operating at different output levels. In some cases—if, for instance, there have been sharp month to month fluctuations in the amount of service a facility has been called on to furnish—records kept over a relatively short span of time may supply you with data showing the actual costs which have been associated with a variety of different outputs as illustrated below:

Table 1

	MAY	JUNE	JULY	AUGUST
Output (Units)	4,000	5,000	2,000	3,000
Costs (Dollars)	36,000	46,000	19,000	27,000

Comments:

For purposes of analysis, the *only* difference among the four pairs of cost/output observations in Table 1 should be the differences in number of units turned out. In practice, since each pair represents a separate time period, a number of other circumstances may have changed: the price of materials may have risen, for instance, weather conditions may have disrupted operations or other factors may have affected comparability. Section 6 discusses ways of coping with this problem.

But if the four pairs of numbers are comparable, you could determine from these data with some degree of confidence how the cost of performing the service (engines repaired, meals served, vehicles serviced, X-rays taken, recruits trained, etc.) was related to operating levels within the 2000-5000 unit/month range. (You would also be able, though with less confidence, to make better cost estimates if the monthly workload were to move outside that range.) Moreover, determining cost/output relationships over the relevant range of outputs would involve nothing more than simple arithmetic. In fact, you will find this true for most other widely used applications of cost and output numbers.

Your first step in comparing the four different levels of output recorded above would be to convert the total cost for each month into average cost per unit for that month's output:

Table 2

	MAY	JUNE	JULY	AUGUST
Output	4,000	5,000	2,000	3,000
Costs	36,000	46,000	19,000	27,000
Cost/Unit	9.00	9.20	9.50	9.00

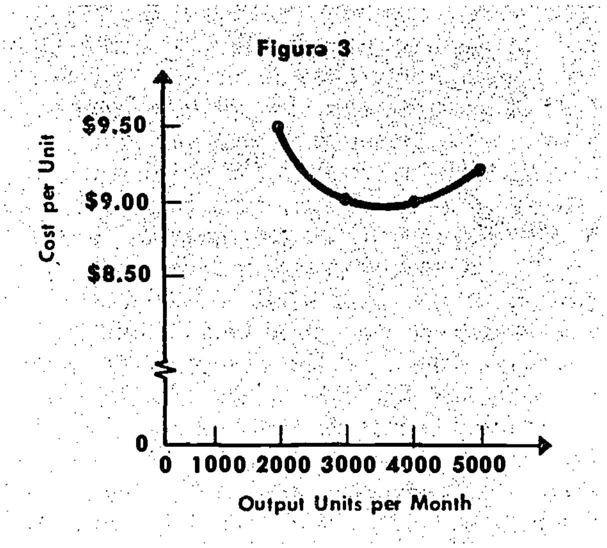
Comments:

Since costs per unit were lower in some months than others (and since we are assuming that the change in volume of work done was the only significant change from month to month and that no addition was made to the facility's physical capacity), it is clear that your facility operated more efficiently at some levels of output than others. But the precise relationship is hard to visualize from the monthly data format.

If the numbers are plotted instead on a graph showing unit costs on the vertical axis and the *amount* of monthly output (rather than its chronological sequence) along the horizontal axis, it quickly becomes apparent that the lowest unit costs were associated with output in the range of 3000 to 4000 units per month. When workloads were either larger or smaller, unit costs rose. A curve joining the points which represent actual observations would take a U-shaped form. (See Figure 3.)

When an average unit cost curve takes this shape, it tells us that the facility in question has a "best" or low-cost rate of operation for its present physical capacity and that operating at any other level—either higher or lower—will make each unit more expensive.

The data *might* have produced quite a different sort of curve—one which sloped up or down throughout the entire range of observations, for instance, or one that was V-shaped or was level over a wide range of outputs. The "U-shaped curve" is customarily used for purposes of illustration because most facilities do

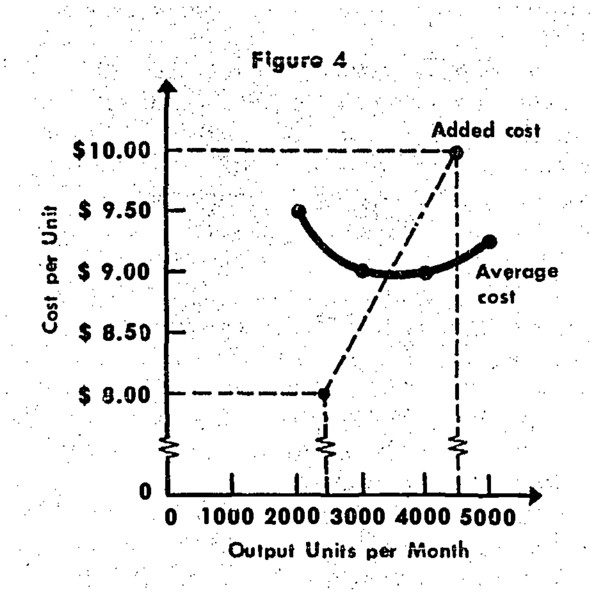


operate more efficiently around the workload they were designed to handle. But some activities can adjust their operations (and their costs) to increased or decreased loads far more readily than others. Where this flexibility does not exist (where a facility's given capacity permits only one efficient level of operation), the curve may be V-shaped so that costs at higher or lower levels quickly become prohibitive. Downward or upward sloping curves, on the other hand, would indicate that your data covered a range of outputs all of which fell short of the facility's most efficient level of operations or, conversely, were already overtaxing its capacity. Only by analyzing data for *your* activity over the relevant range of outputs could you identify the probable impact on your costs of a specific proposed change in output.

A graph like that in Figure 3 would give you important information about that impact, but another way of using the date could tell you considerably more. Most management decisions involve possible changes from some existing level of operations; put in another way, *you always start from where you are* (and usually this is not zero.) Whatever your level of decision making—immediate supervision of a single facility or overall planning responsibility for a major activity—your questions usually concern the impact of *change*, upward or downward, from the existing level.

Analysis which focuses on the changes is sometimes called *incremental analysis* because it is concerned with successive additions to (or subtractions from) outputs and expenditures. Economists call it "marginal analysis" because—at least in principle—these are decisions made "at the margin:" one unit more or one unit less. In practice, of course, changes in the operation of an on-going activity would rarely, if ever, be considered one unit at a time. You would ordinarily be directing your attention to a specific increase or decrease of some minimum size.

Using once again the data presented above, suppose your activity had a current workload of 4000 units per month but that next month you expected it to be 5000—an increase of 1000 units. Figure 3 would tell you that if this change occurred, your average costs would rise from $9.00 to $9.20, and you might infer from this that the 1000 units would cost $9200. But Table 2 tells you clearly to expect your total costs to go from $36,000 to $46,000—a jump of $10,000. Looked at from this perspective, the additional 1000 units achieved as a result of spending an additional $10,000 would, on the average, be costing not $9.20 but $10.00 each. (Note that the point indicating an *average* cost for the 1000 additional units is plotted on Figure 4 at 4500, half way between the 4000 and 5000 unit levels.)



The use you might make of this sobering information would depend on the level of your management responsibility. If your workload were determined entirely by forces outside your control, you would use it to demonstrate convincingly that your budget must be increased by $10,000 to handle the 1000 additional units. (Your budget officer, looking at the $9.00 per unit cost figure associated with your current 4000 unit operating level, might want to give you as little as $9000.)

At higher levels of management, you might consider how urgently the additional 1000 units were needed: Were they worth $10.00 a piece? Could some of this work be postponed until loads were lighter? If the increased workload seemed likely to be permanent, should the facility be expanded to provide new capacity, or could the additional work be assigned to some other facility where additional output might add less to total costs because current operations were below its most efficient level?

If your options included the possibility of expanding the existing facility (or constructing new capacity elsewhere) your analysis would have to take account of additional factors (the time needed to expand capacity, the investment cost, the more efficient scale for a facility of this type, etc.) and would become more complex. Section 5 deals with some of the factors you would need to consider. Further, any decision involving significant capital investment would require application of the analytic procedures outlined in the *Economic Analysis Handbook* cited earlier.

The possible advantages of allocating work among existing facilities can be illustrated from the figures in Table 2. Suppose your current operating level were not 4000 but 2000 units per month. Under these conditions, the table reveals that 1000 more units could be obtained for only $8,000 in additional costs (an increase from $19,000 to $27,000). Your facility would be operating *more* efficiently after the increase than before, and, as Figure 4 shows, the additional 1000 units would be costing, on the average, only $8.00 apiece. The other possibility, an increase in operating level from 3000 to 4000 units per month, would leave efficiency unchanged; total costs would rise by $9,000, the added units would cost $9.00 apiece, and average costs would also be unchanged at $9.00.

The same considerations which are important in assigning additional work also apply in determining the cost savings which might be expected if output requirements were decreased. Again using the data presented in Table 2, if your facility were currently working at the 5000 unit per month level, a reduction in workload by 1000 units would bring it closer to the "best" level of operations for its existing capacity and, allowing for some time lags and friction in cutting back on costs, would permit a monthly savings of $10,000 rather than the $9,000 to $9,200 suggested by the average cost figures.

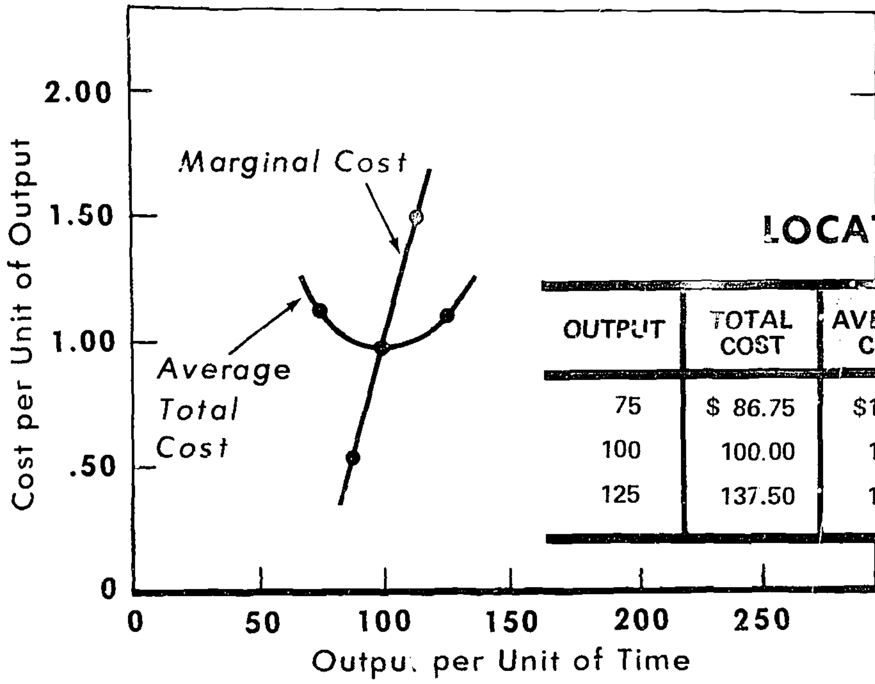
From a current operating level of 3000 per month, on the other hand, a 1000 unit reduction would not save more than $8000. In both cases, the impact of the change would depend not only on the size of the change but on "where you started from." And once again, you as a manager could anticipate what changing output requirements would really mean to you much better from analyzing the incremental change in aggregate costs than from average cost figures.

If your responsibility included decisions on how to allocate work among two or more facilities, you could use this analysis to discover where additional work could be done for the least added cost and where a cutback would result in the largest savings. The answers to these questions would depend not only on each facility's operating level just prior to the proposed change ("where they started from") but also on the shape of the cost curve at each.

Suppose two facilities are engaged in turning out the same work—engines overhauled, vehicles serviced, meals served, X-rays taken, recruits trained, etc. (Locations A and B in Figure 5). Suppose further that each is currently operating at the "best" level of output for its existing capacity (for purposes of illustration, 100 units), and that each has identical costs of $1.00 per unit when operating at that level. But there the similarity ends. As Figure 5 shows, adjustments in output around this technically "best" operating level appear to be much more difficult (and expensive) at Location A than they are at Location B. The cost curve for Location A approaches the V-shape discussed earlier while that for Location B is nearly flat for a considerable range of outputs on either side of its best level.

These diverse relationships would be very significant if you needed to increase *combined* output for the two facilities to 225 units or if overall requirements fell to 175. As the numbers beside the graphs indicate, Location A is already operating at the *only* level where the facility

Figure 5

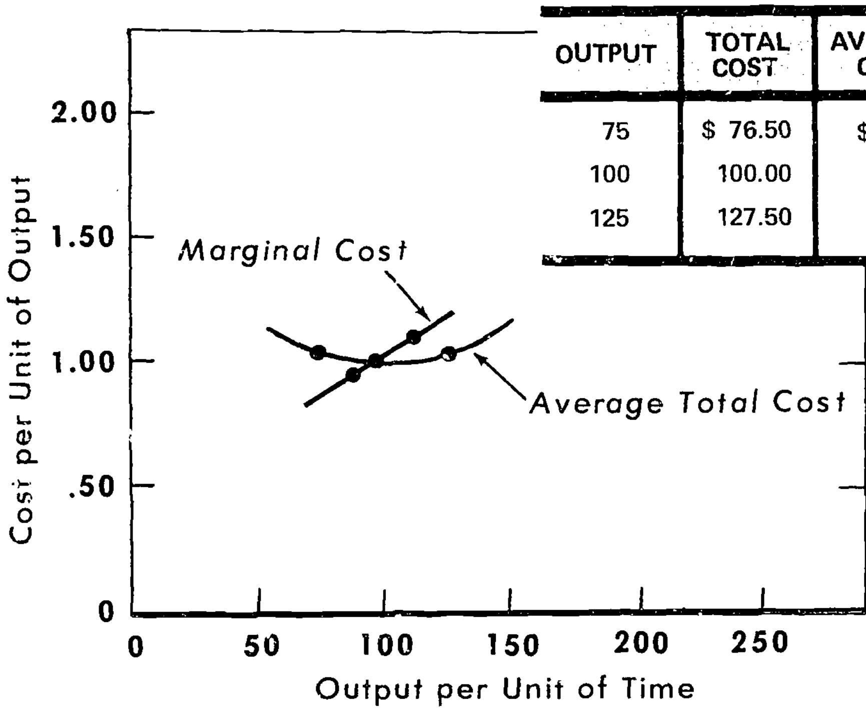


LOCATION A

OUTPUT	TOTAL COST	AVERAGE COST	MARGINAL COST TOTAL	MARGINAL COST AVERAGE
75	$ 86.75	$1.15		
			$13.25	$0.53
100	100.00	1.00		
			37.50	1.50
125	137.50	1.10		

LOCATION B

OUTPUT	TOTAL COST	AVERAGE COST	MARGINAL COST TOTAL	MARGINAL COST AVERAGE
75	$ 76.50	$1.02		
			$23.50	$ .94
100	100.00	1.00		
			27.50	1.10
125	127.50	1.02		

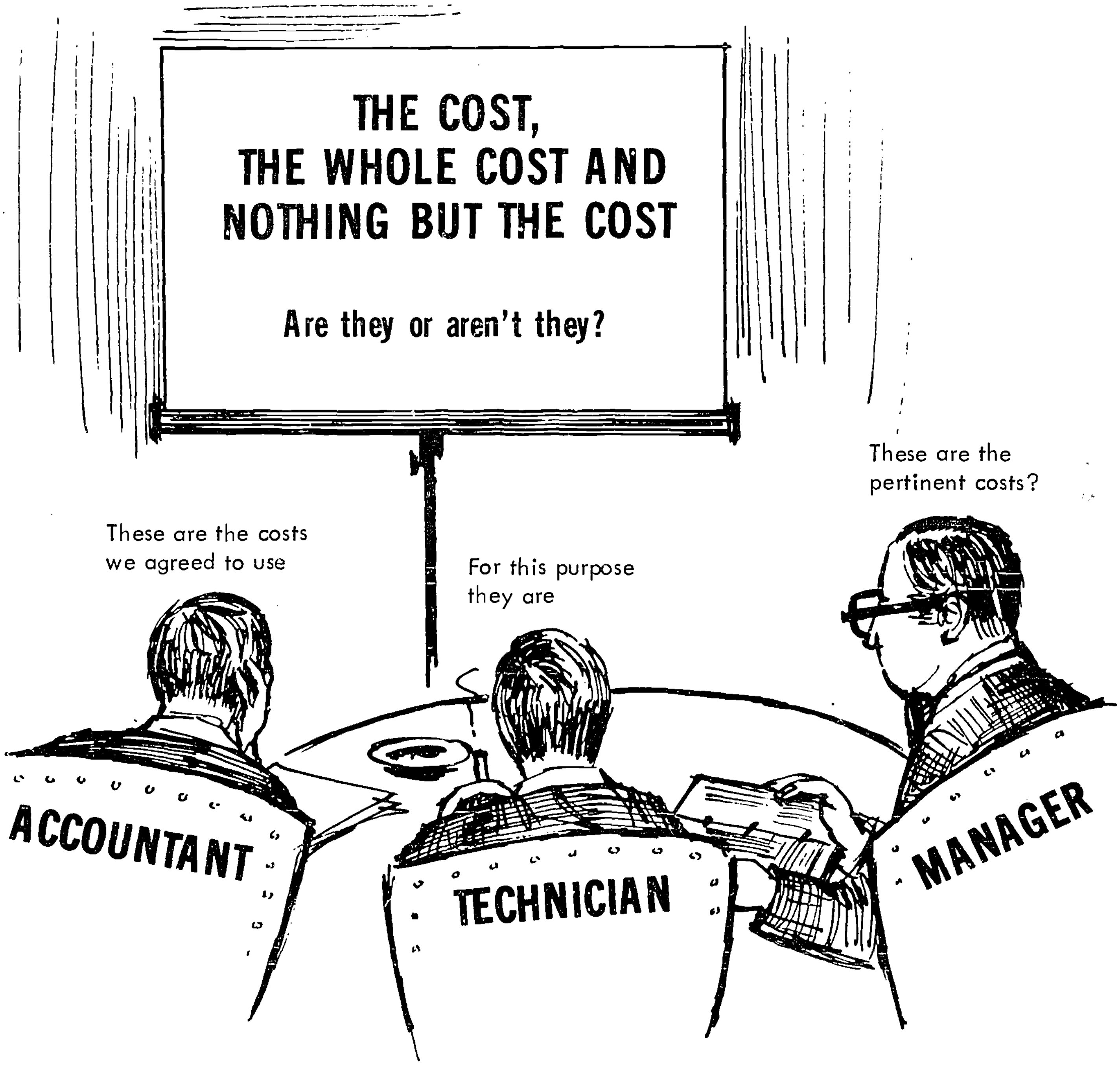


functions efficiently. Short of adjusting capacity through an investment decision, any change in requirements in either direction from that level would be expensive: adding 25 units would boost costs by $37.50 (an average of $1.50 for each additional unit); a cutback of 25 units would save only $13.50. The additional 25 units could be obtained much more cheaply at Location B where the total added cost would be only $27.50 (or $1.10 apiece). On the other hand, Location B would also be able to adjust better to a cutback, that is, the reduced workload would permit a savings of $23.50, $10.00 more than could be saved at Location A.

Assuming that total requirements rose from 200 to 225 and you were free to make your decision solely on economic grounds, you would assign the entire 25 unit increment to Location B. Conversely, if total requirements declined, operations at Location A should remain unchanged while a cutback to 75 units occurred at Location B.

In light of the evidence assembled here, this conclusion is self-evident. But if you did not have quantitative information of the kind described above on the way costs were related to changing output levels at both locations, it would not be evident at all.

II – 3


THE COST,
THE WHOLE COST AND
NOTHING BUT THE COST
Are they or aren't they?
These are the pertinent costs?
These are the costs we agreed to use
For this purpose they are
ACCOUNTANT
TECHNICIAN
MANAGER

3. The Cost, The Whole Cost and Nothing But the Cost

In order to perform the arithmetic of analysis, as described in the preceding section, you need numbers—actual numbers for your own activity. The amount of help that analysis can provide in making management decisions depends largely on the accuracy with which cost and output are measured. Important as record keeping is to this process, more is involved than setting up a reporting format and assigning someone to collect the numbers. This section and Section 4 which deals with output will explain why.

When you read, "It costs 9¢ to deliver an airmail letter." or "It costs $1.50 per meal to feed military personnel," the numbers attract your attention. They are specific, and in print. It would appear that they *are* the cost of delivering letters or providing meals. But a different accounting system might have produced entirely different numbers, ones which might have been either half or twice as large. And any of the three sets might be equally legitimate for the purpose for which they were collected.

If this statement shocks you, it should not. Cost figures do not, and *cannot*, have a single generally accepted meaning. In both government and business, data are collected for a variety of purposes, and the particular elements of cost which should be included depend on the use to be made of them. When cost data are used for the kind of analysis being discussed in these pages, they must meet several criteria. First, they must match—timewise—the output data to which you are relating them. Second, they must include all the cost elements relevant to the particular decision you are making. Third, they must include only those cost elements which are relevant to that decision. Finally, and often most important, they must be interpreted in the light of your own experience and judgment.

How do you decide whether your cost data provide the right numbers for a particular analytic use? The answer depends both on *what* specific items of expense are included as costs in your records and on *when* each item is entered as a cost in those records. The second question is, in many ways, the more crucial since it applies to all types of cost/output analysis. You cannot relate what was accomplished in a particular time period to the resources used in obtaining that output unless you are able to match the two sets of data. And this will not always be the case with figures drawn from government accounts.

Government agencies have always kept detailed records of expenditure, but these—as explained earlier—have traditionally been geared toward control over the use of resources: making sure that obligations to spend did not exceed amounts authorized and that disbursements did not exceed amounts obligated. Since resources are not *used* at the time they are ordered, delivered or paid for, records based on order, delivery or disbursement dates are not useful for measuring the costs associated with particular output.

In 1956 Congress recognized the need for relating specific expenditures to specific output by directing federal departments to prepare budgets based on the expected cost of particular programs rather than dollar obligations or disbursements (Public Law 863). But, for many years, little was done to provide a statistical basis for the budget estimates required by this instruction.

Records providing data on resources *used* during a specific time period (accrual accounting) have become more available in recent years. In 1966 the Department of Defense was the first federal department to begin collecting many cost data on this basis. In the numerous areas where records are now being kept in this fashion, cost data are—for the first time—comparable with measures of accomplishment over the same time periods.

But you still cannot take for granted that all costs for all activities with which you may be concerned are posted at the time resources are used. Remember too, that activities which *do* record costs on this basis also keep other sets of records which show the same expenditures on an appropriations or a payments basis. Accordingly you need to look at the actual numbers you propose to use for analysis to make sure they do, in fact, show resources *used* during the period covered by your output data.

Your second obligation, that of identifying relevant costs (those appropriate for use in your particular analysis), is not so easy to define. In fact, there is no generally applicable rule to use. Items of expenditure may be significant cost elements for purposes of reaching one decision but have no place in analysis directed toward a different problem.

Ideally, you should have a record of all cost items from which to select or exclude those which are or are not relevant to a particular decision. In practice, you may find that your records now omit some numbers which are needed for much cost/output analysis. This happens because we usually think about costs in terms of budgets. As a resource manager, you take account of those expenditures which have an impact on *your* budget. *These are your costs.* But other resources may also be employed in the course of your operations. Are they also *your* costs? Should they be included in your records and used in your analysis?

The manager of a military activity is likely to encounter this sort of problem because, in many cases, the activity's own budget will consist entirely of items included in the O&M appropriations. Military personnel assigned to the operation are paid for out of another appropriation. The labor they supply in meeting your activity's workload is, of course, a cost, but it does not seem to be your cost and is likely not to be entered as such in your records. For many purposes this is a straight-forward pragmatic approach to the management function, concentrating attention on those resources over which you have control and leaving to others the management of those over which you do not.

Such deliberate selectivity will provide the numbers needed for many management decisions. But if cost records are kept *only* on this restricted basis, analysis of the sort explained in the preceding section can yield misleading answers.

Consider an example similar to those in Section 2 which related cost to output over a range of outputs. Suppose, for instance, that your activity provides food service and is currently supplying 40,000 meals per month. Suppose further that your records also include data relating cost to operating levels of 30,000 and 50,000 meals per month. With this information, you can predict the impact on your costs of specific *changes* up or down in the number of meals your facility serves. You can not only estimate future budget needs but also—and perhaps more importantly for higher level management decisions—identify *where*, within this range, your facility operates most efficiently.

Let us assume that *your* budget, and consequently *your* recorded costs, include all O&M items but only those items: food, civilian personnel, labor contracted for, transportation, gas and electricity, cleaning supplies, etc.—a total which varies from month to month depending on the number of meals being provided (see Table 1). In this operation you also utilize military personnel assigned to you but not paid for out of your budget. Since the number of personnel assigned has been constant throughout the period covered by these records, military payroll associated with this item has amounted to $12,000 per month regardless of the number of meals your facility has served.

Parts B & C of Table 1 show two alternative ways of relating the cost of providing food service at your facility to the volume of service provided. Part B considers only your budgeted costs; Part C includes these and military pay as well. For purposes of analysis, which cost basis is relevant? The first and most obvious difference between the two, of course, is that total and average costs for *all* service levels are lower when only those cost items charged against operation and maintenance accounts are included. Since the excluded military labor was both used and paid for, the cost to the taxpayer of providing food service is understated by that amount. But this does not necessarily mean that the numbers are not suitable for analytic use.

Suppose the intended use of this information is limited to preparing *your* budget estimates for expected future workloads and for monitoring expenditures out of the current budget. In this case, you would be concerned only with O&M costs which could be varied according to the service level required. In *both* Parts B and C, the columns headed "Marginal Cost" indicate that an increase of 10,000 meals per month (from 40,000 to 50,000) would require an addition of $17,000 to the budget while a decrease to 30,000 would permit a reduction of only $12,000. This "marginal" cost calculation could be computed from cost figures recorded on either the O&M or the "full cost" basis, but the constant "military pay" item, in itself, is neither necessary nor relevant in determining *your* budget needs.

Suppose, however, that this information will be used to decide the best way of allocating an increased workload among several food service centers. For that analysis, cost data must permit

Table 1

Part A - TOTAL COST

Output (units)	Operation and Maintenance $	Military Pay and Allowances $	TOTAL $
30,000	48,000	12,000	60,000
40,000	60,000	12,000	72,000
50,000	77,000	12,000	89,000

Part B - OPERATION AND MAINTENANCE COST - ONLY

Output (units)	Total Cost		Marginal Cost	
	$	average per unit	$	average per unit
30,000	48,000	$1.60		
			12,000	$1.20
40,000	60,000	1.50		
			17,000	1.70
50,000	77,000	1.54		

Part C - OPERATION AND MAINTENANCE COSTS - PLUS MILITARY PAY AND ALLOWANCES

Output (units)	Total Cost		Marginal Cost	
	$	average per unit	$	average per unit
30,000	60,000	$2.00		
			12,000	$1.20
40,000	72,000	1.80		
			17,000	1.70
50,000	89,000	1.78		

you to identify the volume of meal service at which your facility operates most efficiently.

If cost data are drawn only from your O&M budget and exclude military pay (Table 1, Part B), you would conclude that your "best" operating level was in the vicinity of 40,000 meals per month where average costs would amount to $1.50 per meal. If 10,000 additional meals were served, the cost of the added meals would average $1.70 per meal—or 20¢ per meal *more* than the apparent low cost rate. As a result, the average cost of serving 50,000 meals would rise to $1.54, an indication that the facility was operating beyond its most efficient rate. This analysis would suggest holding operations at or near the 40,000 meal level if practical, and feeding additional personnel elsewhere. If this were not practical, consideration might be given to enlarging your facility's *capacity* to avoid higher unit costs.

But when all costs, including the services of military personnel, are taken into account (Table 1, Part C), this picture changes. On the more inclusive basis, 40,000 meals are being served for $1.80 per meal. The added cost of serving 10,000 *additional* meals would still be $1.70 per meal, but this is now 10¢ per meal *less* than the current average cost (including military pay) and indicates that your facility's capacity is actually *underutilized* at the existing service level. Far from raising average costs, the proposed increase in workload would cause the unit cost of providing service to decline slightly.

For purposes of identifying a facility's most efficient operating level, the labor supplied by military personnel is a relevant cost. Clearly, a manager responsible for allocating meal service among several centers would be handicapped in reaching his decision if available cost records do not permit him to include this item along with other relevant costs for each facility to which an additional workload might be assigned.

Failure to include relevant costs may also affect the validity of comparisons among two or more operating facilities. In the example above, for instance, a comparison between your facility and one operated entirely by civilian labor (whose wages would, of course, be included in its budget) would not be valid unless your recorded costs included military pay for comparable work performed. But, as has already been noted, the military pay item should be shown separately since you may wish to exclude it in considering many questions of internal management.

Indeed, when using cost and output information for analysis, deciding what cost items to *exclude* from a particular analysis may be at least as important as making sure that the records *include* all relevant costs. Management decisions are oriented toward the future, not the past, and are concerned with *choices*. Once a cost has been incurred, management has no choice regarding its outlay for that particular item. In analysis focusing on the composition or level of *future* output, relevant costs are those about which management—at some level—still has the option of spending more or less or not at all.

Short-run operating decisions usually involve increases or decreases in output around a current workload and within a facility's existing capacity. But longer range decisions often involve a wider range of options—changes in capacity, the replacement of obsolescent equipment, the inauguration of major projects or the outright abandonment of existing ones. Some analytic techniques helpful in reaching decisions of this sort will be discussed in Section 5, but it is important to recognize here that, wherever such options exist, the relevant cost items will be those *future* expenditures—*and only those future* expenditures—which could be avoided or greatly reduced by deciding not to begin or expand or continue the output in question.

Once a specialized facility has been built and equipment installed, a decision not to utilize that capacity will not bring a refund of the original outlay; but for projects not yet begun, *all* costs, including research and development as well as construction and other capital investment, may still be optional and therefore relevant. In a military environment, the expected output of the new investment over time (and therefore the amount which would be chargeable against each unit of that future output) would depend largely on judgment.

Record systems can and should display *clearly and separately* all the elements of cost associated with any given activity, but record systems cannot identify which components are appropriate for a particular analysis. You as the user must be prepared to exercise your own informed judgment.

Judgment may also be required in deciding what items of expense are associated with particular output. Consider, for example, cost items which are shared by two or more activities. How should these be divided? One way to split an electric bill among various activities using electricity would be to install separate meters for each, but would the expense required to make such an accurate allocation be warranted? Perhaps minor expense items should be allocated according to a formula or not at all. Only someone familiar with an activity's operation and also with the use to which data will be put can answer such questions.

If an added responsibility is assigned to an office where the work force is already fully occupied, the manager may be compelled to hire another worker. Suppose the new responsibility requires only half of this employee's time. Should his salary be charged entirely to the new activity, or should the added expense be shared by other activities which may benefit from the expanded work force? In cases of capital acquisitions, how should the cost of a new machine be allocated if its full capacity is not being used?

These have been examples of *specific* questions which require an exercise of judgment in measuring certain *specific* cost items. *Far* more pervasive in its impact on the analysis of cost and output data is the existence of *quality* differentials among the resources which managers can choose to combine. These differentials will figure in your management decisions whether you are engaged primarily in operations, research and development, procurement or any other area of activity. In all of these environments, output (accomplishment) results from combining people and things, and most of the necessary skills, materials, services and equipment are available in *several* quality grades. The differences are reflected in their relative prices.

If you elect to use a lower quality of any one item, your recorded cost for that item—when compared with the more expensive alternatives—will reflect the exact number of dollars you will apparently have saved. But your decision to use this less expensive alternative may also have some adverse impact on your other costs or on the quality of your activity's output, or both. Such changes may alter, in some cases dramatically, the story told by the initial price comparison, and if they do, you will need to modify your calculations to take account of those changes.

Suppose, for instance—as was the case recently in a department at a military school—that your activity has been renting a copier (Brand A) that provides first class copies for about 4½ cents each. Funds are not available to consider buying this or any other copier, but price comparisons show that a different brand of copier (Brand X) would turn out copies at 2½ cents apiece. Both prices include rental, paper, ink, service contract, etc. with the only differential between the two lying in the quality of the reproduction itself.

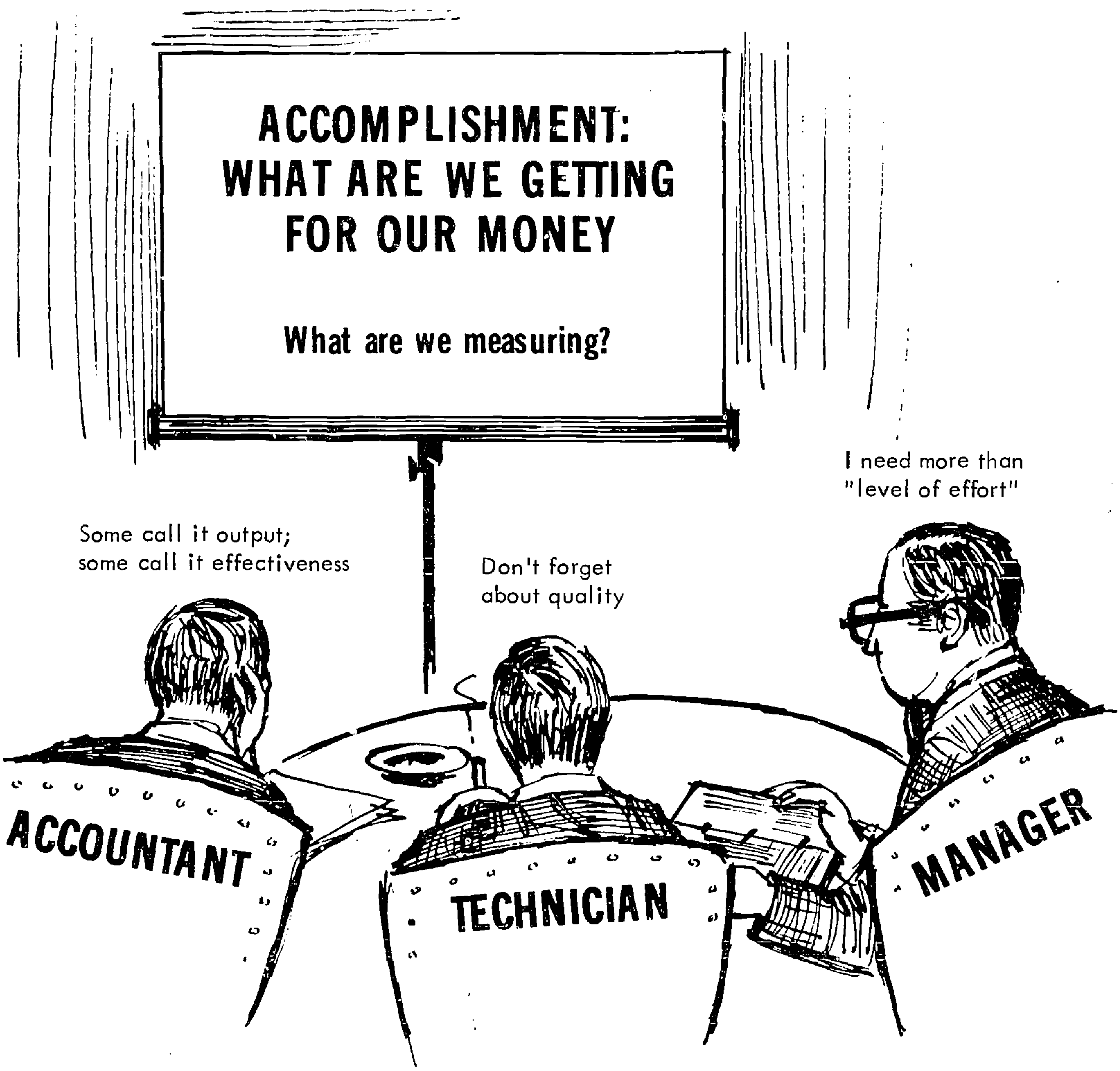
The department at the school concluded that its direct outlays for copying could be cut by about $1000 per year by accepting the poorer copies. The reduction in direct costs you could achieve through a similar substitution would, of course, depend on the use made of the copier in your activity.

But what repercussions might the acceptance of lower grade copies be expected to have on your activity's other costs—or on its output? Quite possibly, none—so long as Brand X copies are, in fact, *good enough* to be used successfully in the same ways and for the same purposes as the higher grade Brand A copies. (This assumes, of course, that purely aesthetic considerations may be ignored.)

In the case of the school department where Brand X was actually substituted for Brand A, however, the change did, in fact, turn out to have unfavorable repercussions both on other costs (it led to increased secretarial workload) and on teaching effectiveness (the inferior copies proved unacceptable for last minute handouts to students and other teaching aids previously available). Such repercussions obviously offset part (possibly all) of Brand X's cost advantage, but they are diffuse, hard to anticipate and even harder to quantify. The dollar figure recorded as a direct outlay on Brand X copies understates their real cost, but no statistical record can measure the extent of understatement; this requires ultimately an exercise of judgment.

In summary, good recordkeeping procedures are vital to good management, but cost records do not and cannot provide a single unequivocal figure for the cost of an activity, project or program. Good records are like a good cafeteria; they supply separately the specific items of cost which were used in your activity over a specified period of time. You will have to match these items with specific output; you will have to decide which items are relevant to the analysis of a specific problem or bear on a particular decision. You will even, in certain cases, have to modify data on direct cost outlays to take account of indirect costs or other factors which may be impossible to quantify in the records themselves. As in the case of a good cafeteria, a variety of dishes will be provided, but only the user of the food can decide what makes up a balanced and satisfying meal.

II – 4


ACCOMPLISHMENT:
WHAT ARE WE GETTING
FOR OUR MONEY
What are we measuring?
I need more than
"level of effort"
Some call it output;
some call it effectiveness
Don't forget
about quality
ACCOUNTANT
TECHNICIAN
MANAGER

4. Accomplishment: What Are We Getting For Our Money?

Suppose you asked five lunch table companions "What did you accomplish in the yard last weekend?" and got five replies. One might say, "I laid out fifteen dollars for bedding plants and fertilizer." Another, "I mowed the lawn." The third, "I put in four hours working in the garden," while the fourth reported, "We finally finished the foundation for our new retaining wall." There might even be someone who said, "I had a couple of interesting ideas while I was sitting in the sun."

Any of these answers would be acceptable in conversation, but none of them actually measure the speaker's accomplishment, and only two are descriptive of *what got done.* Two replies are not even responsive to the question: neither the first speaker's $15 outlay (cost not output) nor the third speaker's four hours of work (an *input* not an output) tells us what improvements, if any, were made in either garden. And the other answers do not quantify the jobs that were done; that is, they do not express output in countable units such as square yards of grass mowed or cubic feet of foundation placed per hour. None of your companions would be able to relate costs meaningfully to accomplishment.

Yet all of these situations can be thought of as representing types of government activity whose managers are expected to explain what use they have made of funds already received and to justify the amounts they are requesting for the future. And each of your lunch companions exemplifies a type of response some managers have made—and are still making—to these questions.

Traditionally, managers of government activities have, like the first speaker, relied heavily on records of expenditure to show what they did with funds received. But the funds were allocated to accomplish some specific objective, not to hire people, buy equipment and pay for supplies. You, as the manager of a government activity, cannot demonstrate that you have achieved your assigned objective by showing that you have in fact *spent* the funds you received for that purpose.

Suppose you try moving to a physical unit of measurement by substituting "man-hours" (a so-called "intermediate indicator" of output) for total dollars spent. You will simply find yourself in the position of the weekend gardener who labeled four hours of work as his "accomplishment." For analytical purposes, this is actually a worse measure than dollar costs since everyone knows that the man with the hoe and the man with the rototiller do not produce the same results in an hour's time.

To show the combined result obtained from all resources, you must find a direct, quantitative measure of output. Of your five lunch table companions, the one who mowed his lawn could most easily meet this requirement. If he knows the size of his lawn and the time he spent mowing it, he could express his output as a specific number of square feet or as square feet mowed per hour. With this measure he could do a number of things—not only identify what he accomplished last weekend but also decide what time to allow for the chore next week or estimate how much mowing-time would be added if he planted more grass in place of the junipers. (He might decide to buy a power mower or to hire his son to do the job.) In short, this output measure would provide him with *information* which might be useful in reaching a variety of decisions.

Similarly, if your activity is a repetitive operation which turns out a flow of readily identifiable end products such as X-rays taken, students graduated or engines overhauled, you may find it relatively easy to select a unit of measurement and to collect output numbers. Moreover, these numbers will do more than simply show what you have accomplished for past expenditures. If they are collected for your activity or others like it over a range of outputs, they can also be used to anticipate what effect any specified change—up or down—in your job assignment is likely to have on costs.

Once you have output records to match with your cost records, you can relate the two sets of numbers graphically as was shown in Section 2 by plotting costs on the vertical axis and corresponding output along the horizontal axis. (Figure 1.) Each cost and output combination within the range covered by your records will become a point on the graph (A, B, C and D), and you will be able to read directly from the cost axis the *additional* dollar outlays that have been associated with changes in output from A → B, from B → C, or from C → D. If you draw a line (curve) joining these actual points, you can

Figure 1

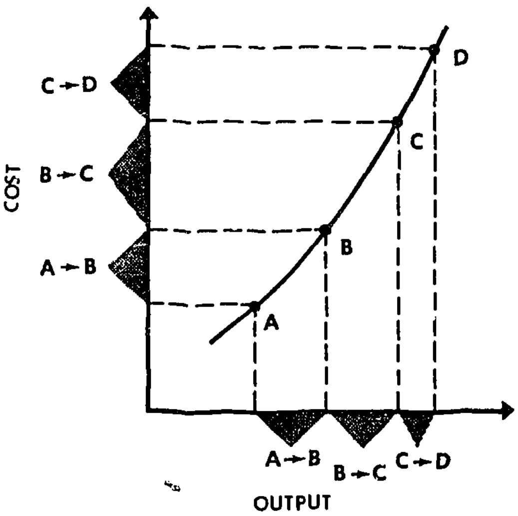
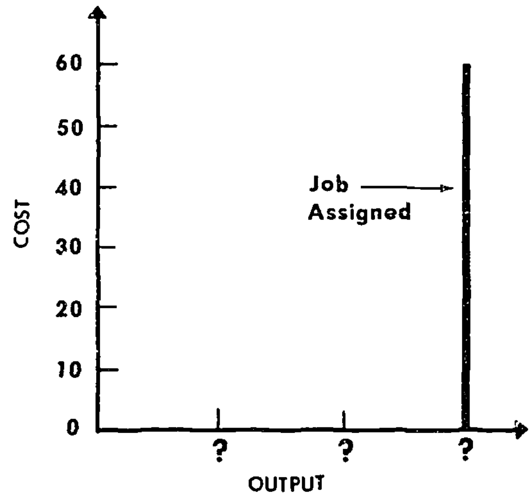


Figure 2



also forecast (on the basis of past experience) the total dollar costs for *any* output level within that range.

Without an appropriate unit for measuring output you could not do either of these things. You could still calibrate the vertical "cost" axis in dollars, but not the horizontal "output" axis (X-rays taken, students graduated, engines overhauled, etc.). Although your cost records would show differing dollar amounts for various time periods, you would not know what the operating level had been in each period, and you could not identify the cost of "marginal" changes. If you were given a future job assignment which represented a change in operating level, all you could do is describe (in words) the new job you would be expected to do. Graphically, this could be shown only as a vertical line placed at some arbitrarily selected point—level of effort—on the horizontal axis. (Figure 2.)

You could then try to find the least costly way of doing that job, but in the search you would not be able to use the very powerful tool of marginal analysis either in the ways that have already been shown in Section 2 or through more precise techniques that will be explained in Section 5. If your activity is one which has an obvious output unit, the benefits of keeping accurate statistical records are obvious.

But suppose you are engaged—not in turning out a continuing flow of identifiable end-products like X-rays or repaired engines—but in carrying out a five-year construction project or in procurement or in research. Perhaps, like your fifth lunch table companion your output yesterday was an idea; can anyone quantify an hour's worth of thinking?

It may seem that there are two distinct categories of government activity—repetitive operations whose output is readily measurable and therefore subject to analysis and another, more variegated range of activities whose managers are excluded from these advantages because their output is not. In other words, it may seem that output measurement has its "haves" and its "have-nots."

But both parts of this conclusion are misleading. Even if you are engaged in an activity where choice of an output unit seems self-evident, you will still encounter pitfalls in measuring output and using the numbers for analysis. If, on the other hand, your activity does not result in a repetitive flow of uniform end products, you will still find many important applications for quantitative analysis; to find them you must measure those aspects of your work-load which *are* measurable, compare them with those which are comparable and tailor the uses you make of cost/output information to your own management decisions.

Undertaking a five-year construction project, for example, is similar to the position of the weekend gardener who reported progress on his retaining wall. Weekly, monthly and even annual output consists of progress not completion—a sequence of dissimilar stages from building plans to site preparation and foundation work to electrical wiring and finishing the interior. Illustrations of ways to use output information which are drawn from repetitive operations could not be applied directly to this situation. Each stage of construction would require a different unit of measurement, and information drawn from records for one stage—say, site preparation—would not provide a basis that could be used in the next stage for laying the foundation. In order to be useful, it is obvious that applications of analysis to a construction project must differ from those made in an operating environment such as food service.

For a large scale construction project, cost/output analysis is first applicable in the planning stage when the feasibility and scope of the entire project depend on the planner's ability to obtain accurate cost estimates for each phase of construction. Those estimates become more accurate and reliable if they are based explicitly on quantitative analysis. The records from which data for each phase can be drawn must relate to earlier construction in a relevant size range, with output units suitable for that particular stage—acres cleared, cubic feet of concrete poured, linear feet of wiring strung, etc.

Once construction is underway, records are maintained for purposes of management control over the project, and the appropriate "unit of measurement" would be geared to this need. Since a prime objective of management is to match actual progress with expectations and actual expenditures with cost estimates, each successive stage of construction may be considered an output unit in this process. A data format like that illustrated in Section 1 will provide usable information rather than mere numbers on the project's current status.

This is only one instance of ways in which cost and output data may be adapted to activities other than repetitive operations. The application of numbers to analysis does not start by collecting numbers but by deciding what *comparisons* would be helpful in making decisions and then selecting units of measurement which can be used for those comparisons. Different measures may be required for different purposes.

Possibly the reason most frequently given for not collecting and using output data in a particular activity is the feeling that its output cannot be quantified—that the task performed is too diverse or too qualitative to be expressed successfully in numbers. This problem is actually one of degree. Few operations are so routine that quality variations can safely be disregarded; numerical units of output are not, in themselves, an adequate measure of *accomplishment.*

In fact, one of the pitfalls of output measurement systems is that managers who find an obvious output unit may ignore qualitative factors in their analysis. The following pages consider ways of bringing quality changes explicitly into the process of decision making. If you have been discouraged from using output data for analysis in your activity by the obvious significance of qualitative factors, these techniques may help you find more precise ways of relating costs to accomplishment. But they are also addressed—perhaps even more directly—to those who have found appropriate output units for their activities without difficulty and are collecting accurate numbers. Those in the latter category need to remember that these numbers measure only the activity's operating level and not necessarily its accomplishment.

As early as April 1968, the Department of Defense stated in a directive that output statistics "must be relatable to significant organizational missions and functions . . . and to resources allocated and consumed." This directive assigned a dual function to output measures. A measure of operating level clearly satisfies the second of these: X-rays taken, engines overhauled, or ton-miles of freight moved are all relatable to resources consumed over the same time period. But an organization does not fulfill its *mission* by turning out a specified number of units; it fulfills that mission by meeting a specified need, and by maintaining a specified quality standard.

The mission of a transport organization is not to move freight but to see that items are delivered where they are needed when they are promised and in usable condition. The mission of a recruit training base is not simply to graduate trainees but to make sure they have specified skills.

In both of these organizations, the "product" has two dimensions: one of *volume* (ton-miles of freight moved, number of recruits graduated) and one of *specifications* (standards set and maintained, such as damage-free deliveries made on schedule or the competence of trainees to do particular jobs). Whatever your activity, its performance will be judged on the basis both of *volume* (physical units of output) and of *quality* (how adequate its specifications are and how well they are met).

Moreover, if you are considering possible changes for the future, your options may include changes in either volume (operating level) or specifications (quality level) without *necessarily* changing the other. Either sort of change might be expected to increase (or reduce) your costs and also to increase (or reduce) the extent to which your organization is meeting its specified need. *Either* type of change (or some combination of both) would be a "marginal" change in output. But if you are using an output measure such as number of engines overhauled or ton-miles of freight moved the data will show only those changes which expand or cut back the *number* of units turned out.

Such a measure will be perfectly serviceable for day-to-day operating and budgetary decisions so long as you are able to make a working assumption that the quality or service level of the units counted remains constant. When you relate output—as measured by this yardstick—to comparable costs data for the same period, you can put the resultant statistics to all the uses demonstrated in the preceding pages. You can estimate budget needs for different levels of future operation, identify your facility's best operating level, compare your facility with other similar ones or decide where to allocate an increased workload among two or more facilities.

But there are other decisions for which measures of operating level alone will not be enough. Such measures tell how many engines were repaired in a given time period, but not how reliable those engines have been after being put back into service; how many ton-miles of freight were moved, but not whether delivery schedules were met; how many recruits were graduated, but not how well prepared they were for their subsequent assignments.

Whatever your activity, its costs of operation (and your future budget needs) depend not only on the amount of work required but also on *how well* it is expected to be done. While many day-to-day management decisions can use cost/output statistics which ignore this dual relationship by taking quality level for granted, program evaluations and long-range planning cannot. Someone, at some level, decides—either explicitly or by default—how good is good enough. If the manager of an operating activity does not want this decision made by default, he should be able to define the existing quality or service level of his activity and to show how much improvement could be achieved with a specific budget increase, or alternatively how much deterioration would follow a specific cut in funds.

We have defined an operating-level output measure as one capable of recording the *number* of an activity's end products per time period over a range of outputs. For mission oriented analysis, an additional measure is needed—one capable of recording that product's *quality level* over a range of levels. This measure should be independent of the unit used to measure operating level since decisions to change quality levels are likely to differ from decisions to change the number of output units. And like the unit used to measure operating level, it should be relatable to costs. Unless you are able to relate service levels to costs, analysis can be of little help in making decisions which involve changes in quality.

Suppose an air transport operation is responsible for delivering freight to a certain destination and that accurate records are kept of the volume moved (in ton-miles), but the level of service is undefined; that is, a standard transit time has not been set or maintained. Constant complaints might convince the director of this operation that present service was not satisfactory, but what sort of case could he make for funds to speed up schedules and make them more reliable?

Without being able to define the existing quality of service, he could neither specify the amount of improvement a given budget increase would make possible nor request the amount needed to achieve a given improvement. He could only testify to his belief that the existing service was inadequate and then submit a budget based on the measurable cost of handling next year's expected freight volume at current (unspecified) service levels plus an additional sum (whatever he thought reasonable) to be used in upgrading service (again to an unspecified extent). *This is not good enough.* To make a strong case for appropriations to improve an organization's mission performance, the manager needs to show how mu ` improvement could be provided for a specific outlay.

For this purpose, the ideal measure of an activity's *service level* would be a single numerical unit like that used to measure operating level. With such a measure, you could present a budget for your activity and say with confidence that a five percent increase in expenditures, for instance, would permit a ten percent improvement in quality of service. Unfortunately, for most activities such a unit would be hard to define and the appropriate numbers even harder to collect.

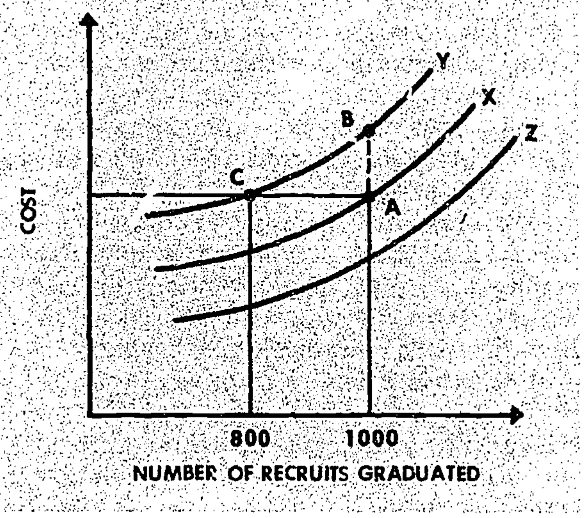
But if there is an explicit *standard of performance* prescribed for your activity, you can use this standard in conjunction with a numerical measure of end-products to define your current performance level. In measuring quality of output, as in measuring output level, you "start from where you are." If you were to draw a graph for your activity like that in Figure 1, the costs associated with each output plotted on the horizontal axis would be those required to provide this existing service level. You can "measure" proposed or actual changes in quality as deviations from that level.

How precisely you can predict the effect a specific change in performance standards would have on actual performance and on costs will depend on two factors. One concerns the type of standards applicable to your operations: they may be precisely quantitative (permissible tolerances for retooling engine parts) or broadly descriptive (the curriculum at a training base and the proficiency scores required for graduation). Second, your output may or may not be subject to routine testing for purposes of administrative control. The more explicit the specifications and the more rigorously they are adhered to, the more precisely you can identify quality changes and relate these to costs.

But in any case, the analytic approach can be demonstrated very simply with a graph like that in Figure 3. Suppose you are operating the training base mentioned above and the solid curve X (based on actual cost and actual output records) shows the cost of training varying numbers of recruits to meet currently accepted standards of skill. If you are graduating 1,000 trainees in each class, Point A on this curve indicates your present level of operation and the cost associated with that level. The added cost of increasing class size by a given number of students would be indicated by moving up to the right along curve X; budget savings would be possible by cutting back the number of students (moving down the curve to the left).

But decisions to tighten or ease training standards are as much marginal decisions as those to change the number of recruits trained. Each

Figure 3



modification in existing standards would add to costs or permit their reduction, and Figure 3 shows how you can represent graphically the added expense or saving associated with a proposed change.

A recruit trained to a higher level of skill represents a different and more costly end product than one meeting the existing standard. The cost of bringing varying numbers up to this higher level would lie along a new (estimated) curve Y somewhat above and to the left of X; every possible number of graduates at level Y would represent a greater aggregate expenditure than the same number trained to level X. The added cost of raising skill levels for a given number of recruits from X to Y would be measured by the vertical distance between the two curves at that point on the graph.

While curve X is based on records and reflects actual experience in training recruits according to the present curriculum, the distance between X and Y would have to be estimated from the component *costs* needed to raise training standards (more time, more instructors, more training materials, etc.). Since these additional costs might not be the same when the training base was operating at different levels curve Y would not necessarily parallel X at all points. Like Y, the curve Z is an alternative curve, but one representing the costs that would be associated with a less rigorous and therefore less expensive training program.

With such a family of curves—and there could be many lines representing more or less ambitious program revisions—you would be able to visualize *either* the extra cost of training all 1,000 recruits to the proposed higher standard of skills (point B) *or* the cutback in class size (to point C—800 recruits) that would be required if you were to stay within your present budget and still adopt the new training program.

Of course, not all management decisions would permit such trade-offs between quantity and quality. If you were reviewing the costs of maintaining a building with a given amount of floor space, for instance, your "choices" would ordinarily relate only to the *level* of maintenance not to the number of square feet to be maintained. For equipment used in space flights, on the other hand, no reduction in maintenance standards would be acceptable, so variations would have to be in the number and type of missions flown.

But in situations like that represented by a training base where changes can be made in numbers, curriculum or any combination of the two, Figure 3 provides an analytic technique for pulling together the full range of options open to a mission-oriented and cost-conscious policy maker. What it does not do is answer the ultimate question: Which option will enable the training base best to fulfill its mission? That decision must be made on the basis of judgment and experience.

Note that the vertical distance between lines X and Y does not measure the extent of quality differential between graduates of the existing course and those who would complete the proposed program. It measures, instead, the cost differential for the inputs that would be required to operate the more ambitious training program. The amount of upgrading in skill that would be achieved through this more expensive program is *defined* as the difference in specifications for the two courses and the relative levels of proficiency demanded in each. This list of differences would provide a detailed and explicit description of the additional training each recruit would receive and the higher proficiencies he would be required to demonstrate.

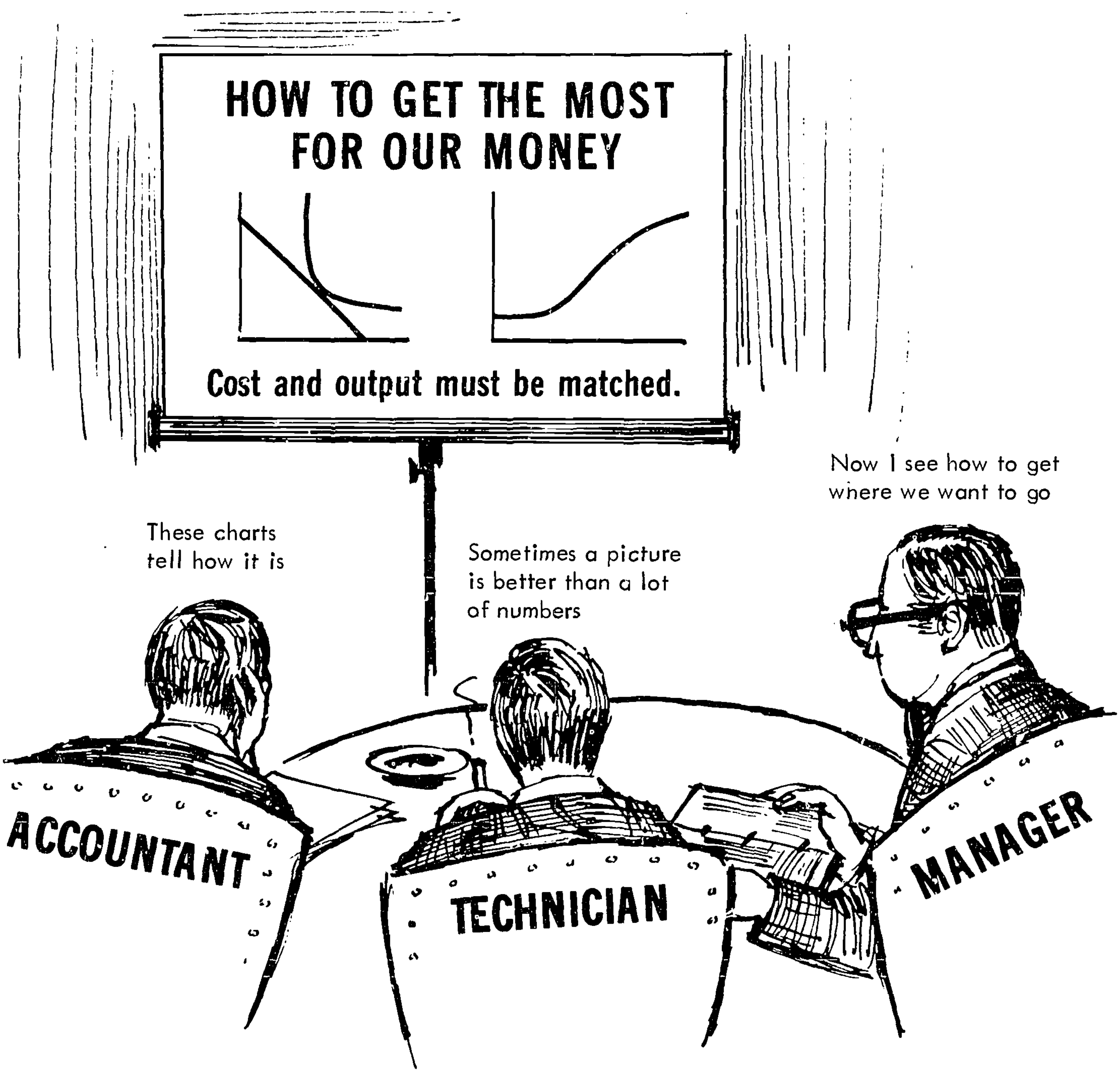
How much better equipped for future assignments recruits would be as a result of this training remains—at least to some extent—a matter of judgment. The numbers in Figure 3 would give you the capability of matching a range of class sizes with costs for both present and proposed training standards. They would enable you to relate specific changes in *either* quantity, or quality (or both) to specific outlays. The numbers would not relieve you of the need to exercise judgment but they would make it possible for you to exercise better judgment. Unless you know what a specific quality change would cost, you can hardly decide whether or not it is *worth* what it would cost.

Obviously in any particular case, the relative importance of judgment and quantitative analysis will depend on the circumstances. In some situations the numbers themselves may come close to providing a definitive answer. Suppose a statistically demonstrable relationship exists between engine life and precautionary maintenance, and you are called on to decide how extensive (and expensive) a maintenance program to set up. If you can identify the additional expenses that would be associated with specific proposals to increase the frequency and thoroughness of routine maintenance, you may be able to caluclate precisely which proposals would produce additions to engine life that exceeded their cost and which would not.

At the other end of the spectrum, suppose you are a research director passing on staff proposals for a series of experiments to test a particular hypothesis. You too would need numbers—cost and output information—to determine what resources would have to be allocated to carry out these experiments. But such information would be of secondary importance unless you had first concluded that the proposed experiments were relevant to a problem worth solving and that the hypothesis was promising enough to be worth the cost of testing.

The usefulness of output numbers in decision making is most direct for activities which turn out a stream of relatively uniform end products. But output *information* (numbers combined with *explicit* specifications or service standards) is important to all managers whether or not they can quantify their activity's ultimate mission. The better *your* records are for the *measurable* aspects of your job, the better judgment you will be able to use in those decisions which depend, in the last analysis, upon the exercise of judgment.

II – 5


HOW TO GET THE MOST FOR OUR MONEY
Cost and output must be matched.
Now I see how to get where we want to go
These charts tell how it is
Sometimes a picture is better than a lot of numbers
ACCOUNTANT
TECHNICIAN
MANAGER

5. How to Get the Most for Our Money

Management decisions, like New Year's resolutions, are directed toward the future. By the time cost and output numbers have been collected and recorded, they are history.

Historical records provide a basis for post mortems; they permit comparisons between what was expected and what was attained. They permit comparisons between your activity and other similar ones. They permit you to formulate future plans on the basis of past experience. They do *not* tell whether past results were the best that could be achieved with the budget available or, alternatively, whether the same results could have been achieved for less money. Even if conditions have not changed, conclusions drawn from historical records and applied directly to current decisions would simply enable you to repeat history. This is not enough.

When we use resources (people and things) to accomplish a purpose, we want to be sure we are using them in such a way as to get the most for our money. To achieve this objective we need to know—at least approximately—how costs would be affected by using alternative *combinations* of resources. We also need to know—at least approximately—how costs would be affected by changes in assigned *levels* of output, either at a single facility or among a group of facilities with different operating levels.

Almost any job can be done in more ways than one. An office manager may handle a higher workload either by hiring more clerks *or* installing more sophisticated equipment (or some of both). Bulk cargo can move by truck, barge or train (or a combination of these). Hospital services may be provided through separate facilities in a number of locations or centralized regionally. Ideally, each decision maker should be able to identify all eligible alternatives for reaching a specific level of output and meeting specified quality standards and then choose the best.

The "best" alternative in a particular set of circumstances will not necessarily be the least costly one in dollar terms. Conserving some resource that is likely to become very scarce in a few years may be an overriding consideration—water in an arid region, gasoline during an oil shortage, possessors of any specialized skill that requires years of training; these are all possibilities that come to mind. But under most conditions, the relative scarcity of particular resources is likely to be reflected in their market prices, and the decision maker needs only to identify which way of carrying out his assignment has the lowest total price tag for all relevant costs.

Please note that, after identifying this low cost alternative, a different course may still be chosen. Suppose, in the example noted earlier, that analysis showed a specified quality of hospital care could be provided most economically at a large centralized facility. It might still be decided that convenience to patients and their families justified greater geographic dispersion. Identifying the least costly way of providing service does not eliminate other options. But by providing a basis for comparison, it puts a price tag on them. It displays the cost of choosing each alternative.

This section does not provide a formula for identifying the least costly way of reaching specific objectives or of establishing what output levels should be required. What it *does* provide is *an analytic approach for comparing alternatives*. The numbers you use in making comparisons among your particular alternatives will be drawn partly from actual cost and output records (past experience) but will also include estimates (past experience modified to incorporate proposed changes in specifications, in output levels, in time schedules, in the prices of relevant cost items).

If data can be assembled for the alternative ways of carrying out a specified assignment, the techniques described below will help in identifying the least expensive way of combining cost items. Such a "least cost" combination is called an "economy solution." If, on the other hand, you start with a fixed budget allocation, these same techniques could be used to identify the maximum results which could be achieved with that budget (an "efficiency solution"). And if your options include choosing among several output levels—either for a single facility or for several—the level which results in the lowest cost per unit would identify the most efficient *scale* (size) of operations in your activity. For a number of technical or policy reasons, you may not achieve these solutions immediately or precisely, but analysis of alternatives can help you make better management decisions.

We often think of choices among alternatives as "either-or" propositions: Shall I drive the car to work this morning, or ride the bus? But the choices managers face in finding the best way to carry out a given assignment are more likely to require decisions on "how much of each." You, as a manager, are responsible for *combining* resources (people, buildings, equipment, supplies, materials, etc.) to accomplish a purpose. You may "mix" these resources in widely varying proportions, but neither an empty-handed workforce nor undirected machinery (automation notwithstanding) will get a job done. When considering broad resource categories, all managerial assignments demand "some of each."

Such physical requirements of "production" may seem applicable primarily to factories or repair shops, but they also apply if you are managing an office or a hospital, directing research, controlling inventories, or providing transportation. In each case, the process of identifying the best "mix" of human and material resources for a particular task is still "analysis."

Suppose, for instance, your immediate mission is to move specified ton-miles of cargo by air to several specified destinations within a time frame which does not permit round trips or round robin flights to more than one destination. Suppose further, aircraft of Type A could make all deliveries in 10 flights, but Type B transports would need only 5 flights to complete the assignment. Flights by Type A aircraft cost \$400 each as compared with \$1000 for a single flight by the large B transport.

Your first reaction would probably be that this is an "either-or" decision. Ten flights by aircraft A would cost \$4000 as against \$5000 for 5 by Type B. This would seem to make aircraft A the obvious selection. But your choices are *not limited* to 10 of A or 5 of B; you might move some cargo by Type A and some by Type B.

Again your first reaction might be that this physical possibility is irrelevant since transport B seems to have twice the capacity of aircraft A, and therefore substituting a B flight at \$1000 for two A flights at \$800 would merely add \$200 to your costs. But, and *this is of crucial importance*, you cannot assume that, on this particular mission, one B flight would always replace precisely two A flights.

If bulky or oddly shaped items make up part of your cargo, the dimensions of one plane or the other may be more suitable for those particular items. The quantity to be delivered at one destination may warrant using a larger transport for that run than would the amounts destined elsewhere. And since the 2 for 1 substitution ratio between aircraft B and A may not apply to all flights, you cannot be sure you have made the best decision for this particular assignment without identifying individually the combinations of A and B flights capable of carrying it out.

Quite possibly, you might find the actual alternatives to be as shown in Table 1.

Table 1

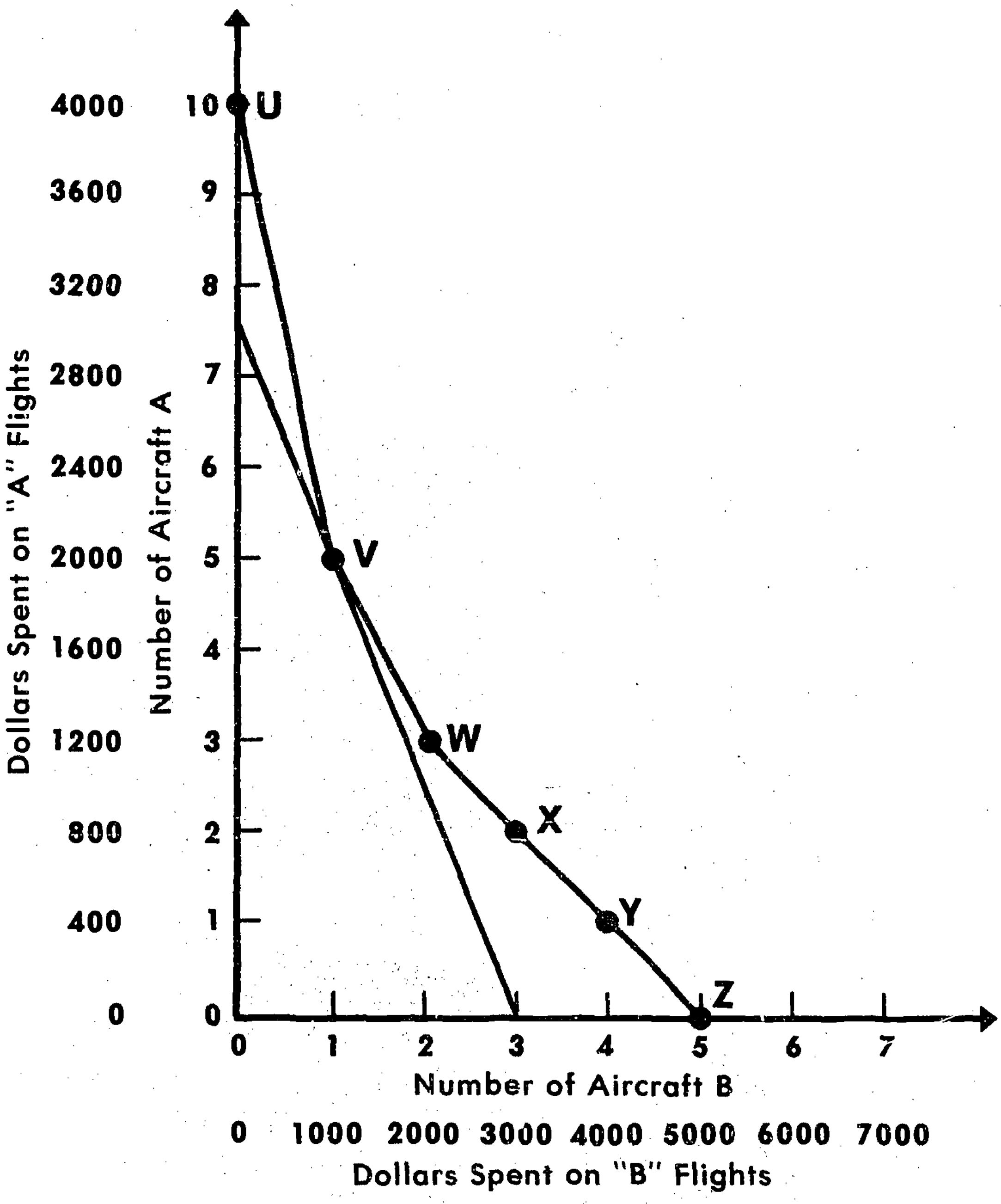
Possible Alternatives	No. of Flights		Total Cost (dollars)		
	A	B	A (@\$400)	B (@\$1000)	Combined
U	10	0	4000	0	4000
V	5	1	2000	1000	3000
W	3	2	1200	2000	3200
X	2	3	800	3000	3800
Y	1	4	400	4000	4400
Z	0	5	0	5000	5000

These same data are displayed graphically in Figure 1 with flights by aircraft A measured on the vertical axis, those by aircraft B on the horizontal, and *each combination capable of providing the required transportation* plotted to show the six possible alternatives. With this profile you can more readily visualize the impact on your total costs of substituting one or more flights by Type B transports for some of the 10 flights which would be needed to complete the assignment with Type A aircraft alone.

The first and most significant observation is that the larger Transport B would be extremely effective for handling part of the shipment. By scheduling a single flight of aircraft B, you could dispense with 5 flights by aircraft A. This might happen because some items had awkward dimensions for loading aboard the smaller aircraft or because enough cargo to make up a full load was being delivered to one destination or for some other physical cause. Whatever the reason, this "tradeoff" (substituting one unit of Input B for 5 units of A) would permit a net saving of \$1000.

But aircraft B appears less well adapted to handling the rest of the assignment. Adding a second flight (Point W) would permit cancellation of only 2 Type A flights (with a net increase of \$200 over the cost of combination V), and in each of the remaining alternatives, high cost Type B flights would substitute for less expen-

Figure 1



sive ones by aircraft A on a one for one basis.

The profile of flight combinations indicates that, by selecting the least costly way of carrying out this particular assignment, the required transportation can be provided for \$3000—\$1000 less than would have been called for by an "either-or" decision in favor of aircraft A.

The same diagram can also be used to show that the specified transportation is the largest amount that could be provided on a \$3000 budget, and that this budget could provide that amount *only* if the funds were spent in the fashion shown. This is demonstrated by the straight line running diagonally through Point V. It is called an "equal cost (budget) line" and shows all the combinations of flights (or fractions of flights) by A and B type aircraft which could be purchased for $3000. The line is significant not as a possible buying guide but because it shows that, even if you could purchase fractional flights, every theoretical $3000 combination of A and B type flights *except* the one represented by Point V would fall short of fulfilling the mission. Except for Point V, the entire budget line lies below and to the left of the combinations capable of providing the specified amount of transportation.

The slope of an "equal cost line" depends on the relative costs of using Type A and Type B flights. In this diagram it slopes steeply because each flight by aircraft B costs two and one-half times as much as one flight by aircraft A. This cost relationship dictates that aircraft B be used only for jobs which would have required more than two and one-half flights by aircraft A.

Now let us add another circumstance to this comparison of alternatives by examining the cost figures themselves. Let us suppose that those used above—$400 per flight for aircraft A and $1000 per flight for aircraft B—are "full cost" estimates, including both the initial cost of the aircraft (spread over its expected useful life) and current operating expenses—those which will be incurred if, and only if, flights are made. But suppose the status of aircraft B differs from that of A in one important respect. Suppose aircraft of Type B are on hand, available for this operation and will, in fact, stand idle unless you put them to use. Suppose that aircraft A, on the other hand, is not owned but is available for immediate delivery. Any Type A aircraft to be used on this assignment would represent a new purchase. In view of the relative status of the two aircraft types, are the $400 and $1000 figures actually the *relevant* (pertinent) costs to use for comparison?

Since you must still decide whether or not to incur the expense of buying aircraft A for this and subsequent missions, the "full cost" estimate of $400 per flight is appropriate. The capital outlay involved in purchasing aircraft A cannot be justified unless the opportunities foreseen for using it now and in the future will be worth at least $400 per flight, including its use in this operation.

But aircraft of Type B are already on hand. The initial outlay, which is represented by—let us suppose—$450 out of the $1000 per flight figure used above, has already been made. Operating expenses (flight crews, POL, maintenance, etc.) make up the remaining $550 and are the *only* costs which would be avoided by deciding against use of aircraft B on this assignment.

As was explained in Section 3, sums which have been irrevocably spent are *not* relevant costs *for future decisions.* They *would* be pertinent for an inquiry into the historical wisdom of deciding to acquire aircraft B. (On the evidence, such a post mortem would have to render an unfavorable verdict; if uses worth $1000 per flight existed for aircraft B, the planes would not be standing idle and available for this mission.) But in comparing the cost of providing a specified amount of future air transportation through alternative combinations of flights by aircraft A and B, the appropriate cost per flight for aircraft B would be, not $1000 as illustrated in Table 1, but $550.

How would this change in the cost figures affect your decision? Using the appropriate relevant cost figure of $550 for aircraft B would not change the appearance of Figure 1 in which the location of points U through Z are determined by the *physical* capabilities of the two aircraft to provide a specified transportation service. But when the total cost of each combination was recomputed to reflect the "relevant cost" for flights by aircraft B, a new "least cost combination" would be identified at point W—two flights by aircraft B and three by aircraft A. (See Table 2.)

Table 2

Possible Alternatives	No. of Flights		Total Cost (dollars)		
	A	B	A (@$400)	B (@$550)	Combined
U	10	0	4000	0	4000
V	5	1	2000	550	2550
W	3	2	1200	1100	2300
X	2	3	800	1650	2450
Y	1	4	400	2200	2600
Z	0	5	0	2750	2750

Note that this least costly combination would still justify capital outlays for some new aircraft of Type A despite the opportunity for putting into service Type B transports which would otherwise stand idle. Because of transport B's high operating cost per flight, its use still would be economical only for runs where a single flight could replace more than one flight by aircraft A.

Only the shift from combination V to W would provide a two for one trade-off; further substitutions would be on a one for one basis.

In this example, the specific outcome is unique to a particular mission with special cargo characteristics, amounts of freight being shipped to given destinations and time schedules to be met. In many management situations—particularly if you are not conducting a repetitive operation—the choice among alternative ways of accomplishing a specific objective may depend on just such a detailed knowledge of special circumstances. You must be familiar with these conditions, identify the specific alternatives capable of fulfilling your mission (in this instance, the half-dozen flight combinations) and price them out to find the one with the lowest cost.

A more general form of "production analysis" is applicable to repetitive operations which are engaged in turning out readily identifiable end products. This analysis addresses itself first to finding the "least cost" combination of resources for carrying out a specified assignment or spending a specified budget, and second to finding the most efficient levels of output for particular activities and—so far as possible—distributing workloads to take advantage of these. Its answers to both questions take account not only of the physical conditions under which people and things can be combined in a specific activity but also their relative prices.[1]

When two or more categories of input (say the people you hire to handle a given workload and the equipment they work with) can be combined in a variety of ways, it would be cumbersome or impossible to price out every possible combination. Fortunately, this is not necessary. When you are seeking the least costly manpower/equipment combination, the eligible alternatives will follow a predictable pattern reflecting the physical requirements of the work being done.

These requirements can be illustrated in terms of any operating facility—say, one making automotive repairs. If you found yourself in charge of a superlatively equipped workshop with a heavy workload but only one mechanic, it would be obvious that a second mechanic could contribute more to meeting the schedule than some of the less essential equipment. You would make such a trade-off immediately. But if you embarked on a process of disposing of more and more equipment in order to hire additional mechanics, each new-comer would contribute less than his predecessor. The more important job assignments would have been given out first; moreover, after each successive substitution, your mechanics would be getting along with less adequate equipment. The net effect on the shop's operation of each substitution would depend on the balance which existed between manpower and equipment before *that* substitution was made.

Where, in this process of substituting men for machinery, should you call a halt? If you are seeking to complete your assignment at the lowest dollar cost, your real concern would not be with the physical contribution to output made by the last man hired or the piece of equipment he replaced. It would be with the contribution made by the last *expenditure* on manpower as compared with the value represented by the least essential equipment remaining on the premises.

By focusing on these "last"—or *marginal*—expenditures for each category of input and comparing *them*, you could identify the least costly way of combining people and things to accomplish your particular mission. So long as an additional outlay on manpower yielded more per dollar of expenditure than the marginal outlay on equipment, you would have an incentive to try substituting at least a little more manpower for equipment. The incentive would disappear and the "best" combination be reached when each dollar of your "marginal expenditure" on manpower made the same contribution to output as each dollar of your "marginal expenditure" on equipment and other materials.

Here we have a very exact *definition* of the least costly way of accomplishing a particular mission. But in the real world, how can this help find the "best" combination? Certainly a definition does not provide slots for numbers which can be copied directly from your records and converted into an answer. But it does suggest a method for reaching—or at least approaching—the least costly solution by asking and answering *a series of questions.*

[1] *If complete information were available for all alternatives and met certain simplifying assumptions, analytic techniques would yield precise and determinate answers to these questions. For a clearer conceptual understanding of "production analysis," see the appendix to this section where these techniques are developed more explicitly.*

If you ask yourself directly, "What is the best way of carrying out my assignment?" the question may seem almost as unanswerable as "How can we eliminate poverty?" But if you start from where you are and ask, "Would a specific small change in the way I am *now* combining resources bring me *closer* to the best combination?" you can usually have a good deal of confidence in your answer. If your activity is already combining resources in some identifiable proportions, the costs associated with this combination are a matter of record. You would start by considering a single marginal change, say, adding more manpower.

If you concluded that this shift between manpower and equipment would lower your costs for handling the same workload (or alternatively would allow you to handle a higher workload at the same cost), you would have reason to estimate the probable effect of further trade-offs. If, on the other hand, you concluded the first shift was likely to lead to *higher* costs, you might want to consider the probable effects of substituting additional equipment for some of your present manpower. Such questions cannot be answered without using numbers, actual or estimated, but by focusing on a sequence of specific marginal changes, you will be able to mobilize the quantitative evidence needed to "test" potentially eligible alternatives.

In the preceding pages, the term "least cost" combination has been used to describe either that combination of people and things which requires the smallest number of dollars to get a particular job done (an economy solution) or as one which enables you to get the largest possible output from a particular budget (an efficiency solution). If your information in arriving at this "best" combination were accurate and complete, it would not make much difference which formulation you used. The smallest budget with which you could do the assigned job would permit you to complete it if—and only if—you allocated that budget among people and things in the most efficient manner.

But in the real world data are less than complete, estimates less than accurate, and performance subject to improvement or deterioration. Accordingly, you might find that your budget was able to cover more (or less) output than anticipated. And if this happens, it becomes important for you to know whether an economy solution or an efficiency solution is desired: whether you should turn out the assigned workload at the lowest cost and make any surplus funds available for other uses, or whether you should strive to achieve the largest output possible with all funds available. Within the limited framework of decision making described above, you would then be operating so as to get the most for the taxpayers' money.

But suppose your authority extends further, and your options include *changes* from the current operating level or in the total expenditures which should be allocated for your activity. Some changes might, of course, be carried out within the physical capacity of your existing facility, but a major expansion of budget or operating level would usually entail capital investments. Before making decisions of this sort, the Department of Defense—as has already been noted—requires that uniform analytic procedures be followed to take account of specified factors (including the present cost of committing capital for long periods and the probable impact of inflation.) These procedures are explained in detail in the *Economic Analysis Handbook* (cited earlier) which also outlines various techniques for estimating the costs and benefits of proposed investment options. Neither will be reviewed here.

What *will* be emphasized, however, is the importance that cost estimates used in making investment decisions—like those used in making operating decisions—should seek to identify, at least approximately, the *least costly combination* of resources (particularly of capital equipment on the one hand and manpower, supplies, etc. on the other) for each output level being considered. Also emphasized is the importance of identifying the *level* at which unit costs would be lowest, i.e. the activity's most efficient scale of output.

This information can seldom be drawn directly from cost/output *records* though historical records for your own facility and others with higher or lower capacities and higher or lower rates of operation furnish a starting point. Data based on experience can be modified to take account of identifiable differences. (Procedures for this are also outlined in the *Handbook.)* In seeking the least costly combination of resources for several possible operating levels, you would use such estimates and then consider the same "marginal" questions you would ask for a single output level: A little more equipment or a little less? A little more manpower or a little less?

If your budget estimates cover a wide range, you would not expect to find that successive increases in the total amount of money made available for your activity were always matched by *proportional* changes in output. For any given activity, some scales of operation will permit more efficient use of resources than others, even though you have been able to specify the most advantageous combination of manpower, equipment and other inputs for each alternative level.

To visualize more clearly such differences in efficiency at various output levels—and to recognize their implications for decision making—a table may be set up like that in Table 3. Suppose your estimates in that Table showed the various workloads which might be handled at your facility with five alternative budgets ranging from $3000 to $7000.

Table 3

BUDGET ($)	UNITS OF OUTPUT	UNIT COST ($)	MARGINAL COST	
			NUMBER OF ADDED UNITS	COST PER ADDED UNIT ($)
3000	100	30		
			20	50
4000	120	33		
			50	20
5000	170	29		
			20	50
6000	190	32		
			10	100
7000	200	35		

In the table, each successive budget shows expenditures rising by $1000, but the associated increases in output range from a high of 50 units to a low of 10. The greatest operating efficiency could be achieved with a budget of around $5000: the 170 unit level where average costs are lowest.

If the facility were already operating at the 120 unit level, a budget increase of 25 percent would enable it to handle better than 40 percent more workload. The 120 units already scheduled would be costing $33 each; Table 3 says another 50 could be added at a cost of $20 for each of the extra units. This does not mean your facility should always operate at the 170 unit level. (The world is full of bankrupts who could not resist a good buy.) But it does mean that a 170 unit operating level is high enough to permit various economies associated with larger scale production (more specialization, use of larger or more sophisticated equipment, etc.). These could not be utilized so effectively by a facility with a 120 unit workload. If this is one of several similar facilities, there might be advantages in consolidation.

On the other hand, the data assembled in Table 3 would not encourage expanding output at a single facility greatly beyond the 170 unit level except in emergencies. Pushing output from 190 to 200 units for instance, would add $1000 to costs in order to achieve 10 additional units. (Larger scale production may also bring diseconomies: bottlenecks may develop; supply shortages may force use of lower quality inputs; in a complex process, breakdowns at any stage are likely to cause far reaching delays.)

Whatever your activity, operations over a wide range of outputs or workloads may be expected to show variations in costs per unit, though these might be less extreme than the numbers selected for the illustration. Such variations would occur even though output at each operating level reflected the best possible combination of equipment, manpower and other inputs for *that* level, i.e. was utilizing exactly the capacity for which the facility was designed. From these variations in cost per unit, you could identify the most economical scale of operations for your activity.

In practice, of course, if your assignment or workload is changing from one level to another, you will often find that the "best" combination of inputs cannot be achieved for the new level without making capacity adjustments. If these would require extensive capital outlays, a decision for or against further investment would have to be made and in any event, time would elapse. Until adjustments were made, the structures already housing your activity and the equipment currently available for carrying it out would be fixed. Output could be increased only by using more manpower and supplies within the limits of your facility's present operating capacity—a more expensive combination of people and things, but the best you could do in the short-run.

The long-run decision would depend on several factors. A temporary bulge in workload might not warrant any adjustment at all. A permanent shift to the new level might lead, over time, to expansion and installation of equipment permitting efficient operation at that level. But suppose it was already clear that the expanded facility would eventually be called on to carry an even higher workload. If you expected to find the new capacity overutilized in the near future, you might recommend immediate expansion to a level capable of handling the projected future workloads in the most economical fashion even though this meant underutilizing some facilities in the interim. If such a long-run expansion would push the facility beyond its most efficient scale (size) of operations, however, you might resist the prospect.

In short, information like that assembled in Table 3 would not tell decision makers how, or in what quantities, to combine manpower, equipment and other inputs, but it would put them in a better position to weigh the relative advantages and costs of each alternative. For any given facility, the best *available* alternative might entail combining people and things "uneconomically" for varying periods of time.

When cost and output records from several facilities over a range of operating levels are used to help identify what scale of output is technically most efficient for your activity, you should be alert to the possibility that some of these facilities may, for one reason or another, either be overutilizing their present equipment or operating with significant amounts of excess capacity.

Likewise in attempting—as managers—to "get the most for our money," we must remember that our specific decisions will depend on the time frame to which they apply. When you initiate a series of "marginal" questions—"How much *additional* output would a specified budget increase make possible?" "Would a further increase beyond that level become more or less costly?"—the answers may be quite different for the immediate future or for a long-run in which capacity adjustments can be made. But whichever time period the decision covers, the analytic approach would be the same.

Moreover, this "marginal" approach to decision making extends beyond proposed changes in method or levels of operation at an existing facility. It is, if anything, more important in the planning stages of a new project or a proposed major expansion or contraction of your present assignment. Here too, you can start—if not from where you are—then from the specifics of the proposal and consider marginal changes in either the way resources are to be combined or the contemplated level of operations. If the first hypothetical "change" seems likely to make a notable improvement, planners would consider moving even further in the same direction; if the probable impact seemed likely to be unfavorable, a shift in the opposite direction might be indicated. In short, before you are committed to either a particular combination of resources or a level or quality of output, you can consider a sequence of marginal changes and "try them on for size."

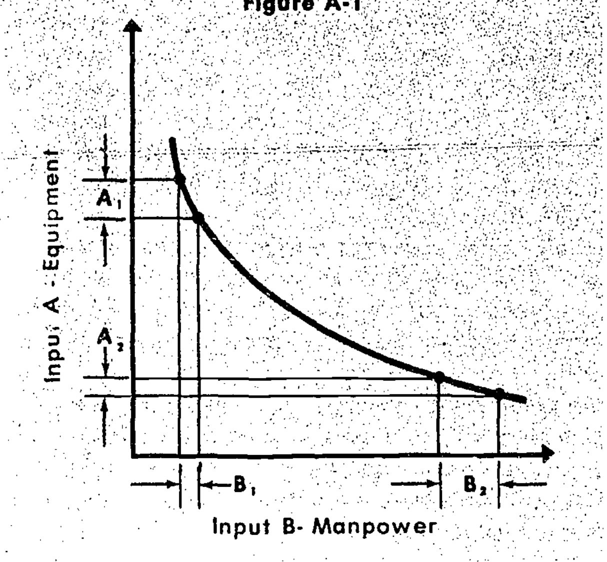
How close this process of successive approximations will bring you to the best possible decisions in view of your objective depends in large measure on the use you make of quantitative data. Many of these numbers will be estimates, but estimates also start from where you are (or have been) in the form of historical records which can then be modified to take account of changes: changes in the proposed amount of the end product or service; changes in its technical specifications, quality or completion dates; changes in the proposed combination of resources, in the prices of inputs, in *any* factor likely to affect the cost of relevant alternatives.

If the data drawn from your historical records were perfect, good estimates would depend entirely on your skill in identifying and making these adjustments. In the real world, however, good estimates depend also on your skill in using imperfect numbers—a topic for the section which follows.

5. APPENDIX: The Theory of Production Analysis

Whenever two physical inputs—say, machine-hours of equipment (Input A) and man-hours of manpower (Input B) can be combined in many different proportions to achieve the same output, these combinations can be shown graphically with amounts of Input A measured along the vertical axis and the corresponding amounts of Input B measured on the horizontal axis. Each point would represent a combination of manpower and equipment with which the facility's work schedule could be met, and the points plotted as successive "equal-output combinations" would form a curve shaped somewhat like that shown in Figure A-1. All of the points on this curve are defined as representing the same quality of work and meeting the same time schedule; in short, each point represents the *same* output.

Figure A-1



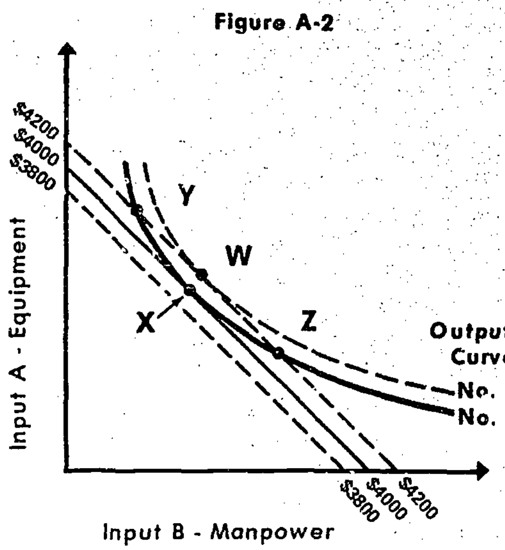
*Of course, other inputs in addition to man*power and equipment would actually be needed to achieve that output (in this instance, some specified workload of repairs made per week). These cannot be shown on a two-dimensional graph, but by assuming that about the same supplies, replacement parts, materials, etc. per output unit would be needed, whatever combination of manpower and equipment was employed, Figure A-1 can focus attention on the various amounts required for these two key inputs.

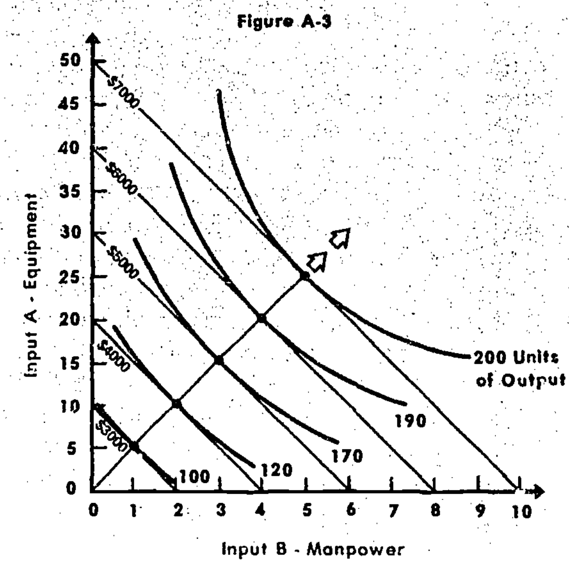
The graph records the effect of marginal substitutions of manpower (Input B) for equipment (Input A). If you made such a substitution at a point on the equal output curve where you were using a lot of A and not much B, a small addition of B (shown as the quantity B_1) would permit a much greater reduction (A_1) in the amount of A required to maintain the same total output. In other words, at that point on the equal output curve, an added unit of B (manpower) would have a higher *marginal product.*

But as the ratio of equipment to manpower (Inputs A and B) declined, use of more B would permit smaller reductions in A, and each successive trade-off would become less advantageous and finally become disadvantageous. (Quantities B_2 and A_2.) Bear in mind that this curve reflects a *physical* relationship and cannot tell you directly when substitutions would cease to be worthwhile in dollar terms. That point would be reached when the dollar cost of your last addition of Input B just cancelled out the dollar savings on Input A. The location of the point depends both on the *relative prices* of Inputs A and B and on their physical ratio of substitution.

You can draw an *equal cost line* for any amount you have budgeted to spend on the combined total of Inputs A and B. If the amount of A you could obtain for the entire budget (say, $4000 per week) is measured on the vertical axis and the amount of Input B available for the same sum is measured on the horizontal axis, a straight line between these points will cover all the ways you could split a $4000 budget between the two, provided the unit price of each input remains constant. If Inputs A and B were completely divisible, you could purchase *any* of these combinations. (Of *course, if the unit prices of the inputs changed* depending on the quantity you used, the cost line would become a curve.)

A higher budget would let you purchase more of both inputs, but (provided the prices of A and B remained the same) the new budget line would have the same slope—be parallel to the first—since the slope is determined by the price ratio between Inputs A and B. The smallest A-plus-B budget with which you can achieve a





particular output will touch that output curve at its least-cost point.

If your assigned workload were represented in Figure A-2 by Output Level 1, this would be the $4000 budget line which includes an input combination capable of yielding Output Level 1. With any lower budget for equipment and manpower you would fall short no matter *how* the inputs were combined. If, on the other hand, you had been given a $4200 budget, *any* combination of manpower and equipment at or between points Y and Z on the budget line would enable you to complete your mission. Input combinations Y and Z would each yield output at Level 1, but choosing either would represent a waste of resources since the same output could be achieved by combination X for $200 less.

If your assignment is to provide end products or services at exactly Output Level 1, only combination X represents the economy solution to your problem. But a $4200 budget would also give you the option of buying larger amounts of manpower and equipment so as to achieve a higher level of output. In this instance, assuming other materials could be made available, the maximum workload attainable in Figure A-2 would be represented by Output Level 2. If you chose to purchase $4200 worth of manpower and equipment, combination W—where the equal cost line is tangent to Output Level 2—would be the efficiency solution, giving you the most for your money.

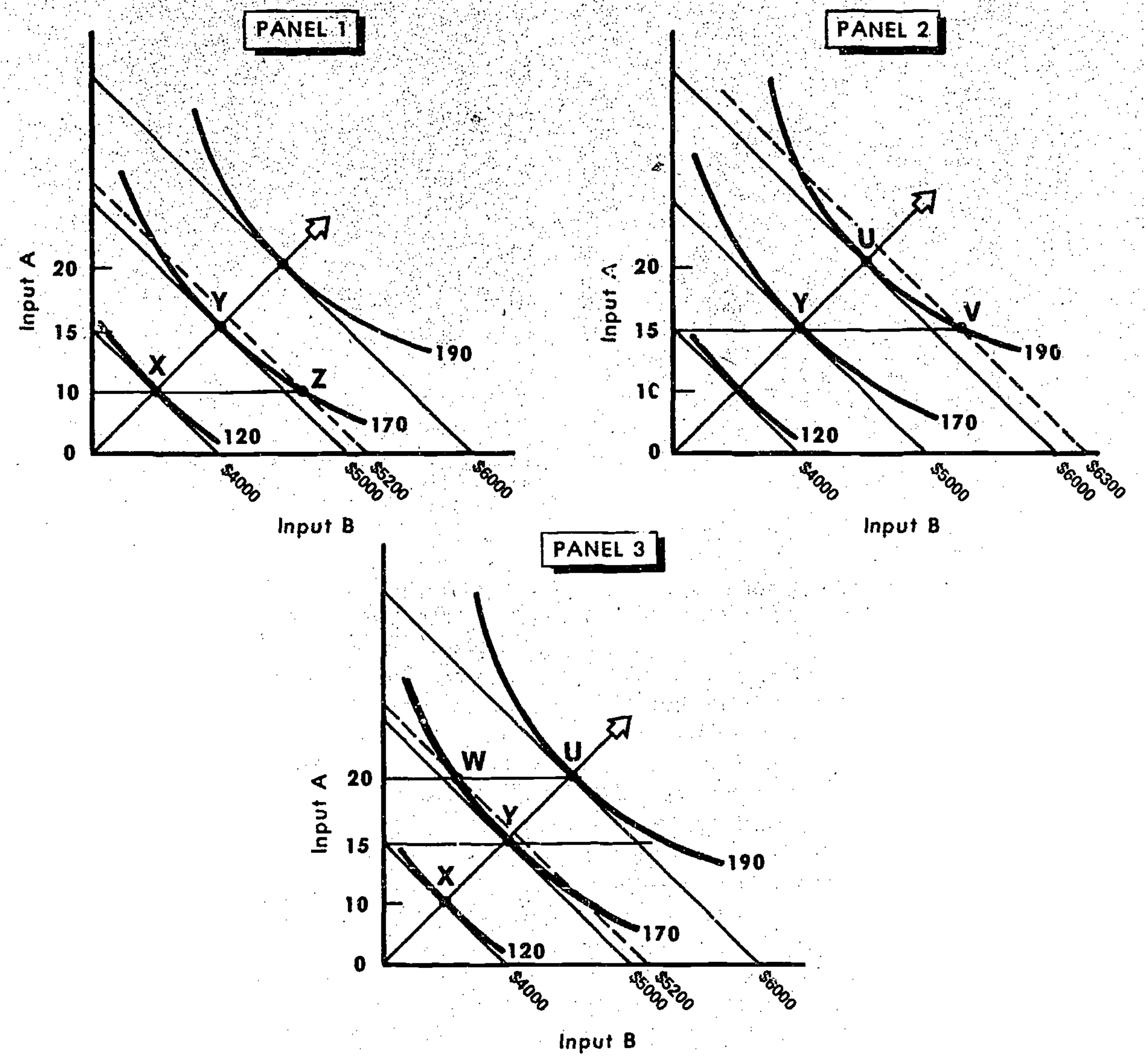
Figure A-3 extends the situation portrayed in Figure A-2 to encompass a range of equal output curves, each of which represents the highest level obtainable from a succession of five budgets, provided each is used to acquire the best combination of equipment and manpower (Inputs A and B). The hypothetical amounts budgeted for combined expenditure on both inputs rise from $3000 to $7000 in equal jumps of $1000 each.

The highest output obtainable from any equal cost line will also represent the least costly combination of A and B anywhere along the highest equal output curve it touches. Consequently, a line drawn through each of these tangency points shows, simultaneously, the most efficient way of spending a particular budget for equipment and manpower *and* the most economical way of using these inputs to achieve a particular output.

Each thousand dollar increase in combined expenditures on A and B provides additional output, but not necessarily the same amount of additional output for each increase. In fact, the numbers assigned to the equal output curves in Figure A-3 show increases ranging from a high of 50 units to a low of 10 units (associated with a budget increase from $6000 to $7000).

In the short-run you might not be able to move *immediately* from one tangency point to the next, since amounts of Input A (embodied in structures, heavy equipment, etc.) would be fixed. Figure A-4, Panel 1 displays such a

Figure A-4



short-run situation when output is increased from the 120 to the 170 unit level. The graph shows capacity adjusted to a 120 unit operating level where you are operating with the least costly combination of Inputs A and B (point X). If you are called upon to supply output at the 170 unit level and cannot immediately increase plant capacity, your only option is to find the point on the 170 unit output curve which *can* be attained with an unchanged amount of Input A (point Z) and employ whatever amount of manpower is required to make good that output.

A capacity adjustment to the 170 unit level is shown in Panel 2 where the new fixed amount of Input A (plant and equipment) is that associated with point Y. But suppose longer-range plans already called for an eventual increase in output to the 190 unit level. An expansion now which adjusted capacity to the 170 unit level might soon result in operations being carried out at point V in order to satisfy future requirements. This would be an "uneconomical" combination of equipment and manpower for a facility operating at a 190 unit level

Figure A-5

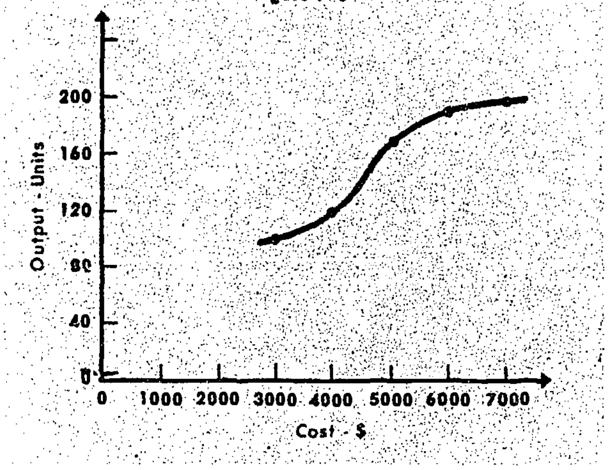
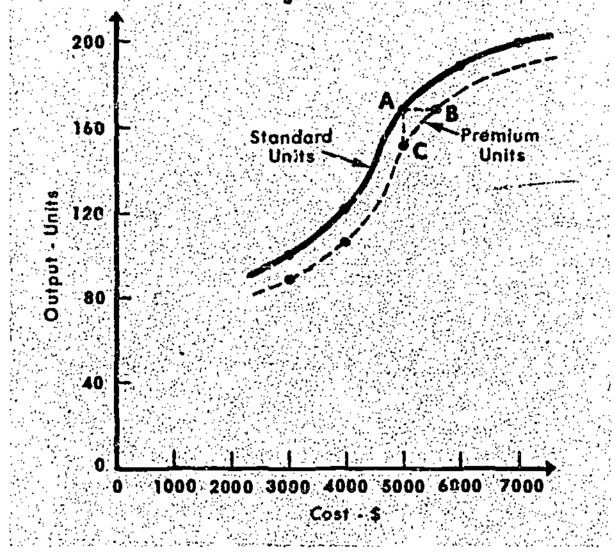


Figure A-6



and, as the budget line passing through point V shows, would add $300 to the minimum cost of handling work at that level.

Given this long-run prospect, you might choose to raise operating capacity immediately to a level which would enable you to handle the 190 unit workload in the most economical fashion (point U on Panel 3). For the immediate future, however, this decision would mean that 170 unit operations entailed an unnecessarily high $5200 outlay on manpower and equipment (point W).

Aside from the time involved in making capacity adjustments, possible combinations of Inputs A and B which do not lie along the diagonal line joining the tangency points in Figure A-3 become irrelevant for long-range planning. Whatever level of output is under consideration, the best way of combining manpower and equipment to reach it will lie somewhere along the upward sloping diagonal joining the points which have now been identified as "least-cost combinations." Each of these points represents a specific output or service level and also minimizes the budget for Inputs A and B needed to reach that level.

We can now set up a new graph, Figure A-5, with the various output levels represented in Figure A-3 measured on the vertical axis and the minimum budgets for equipment and manpower needed to obtain them measured on the horizontal axis. When the least-cost points from Figure A-3 are plotted on this new graph, they will form an upward sloping S-shaped curve from which you can read directly the minimum combined expenditures on equipment and manpower (Inputs A and B) which would be needed to achieve various possible levels of output or service.

With this S-shaped curve, the technique for making marginal comparisons can be extended to identify the cost of changing the quality or service specifications of your output. Output which is designed to meet higher quality standards or more exacting specifications would be a different and more costly end product from the units you are now turning out. Estimated costs for the modified units could be plotted *alongside* minimum costs for the standard units at each output level on a graph like Figure A-5. From this new graph (Figure A-6) you would be able to visualize either the impact on costs of a change in quality specifications at the same operating level (a shift from point A to B) *or* the output which would be lost if an existing budget were stretched to turn out the premium units (a shift from point A to C).

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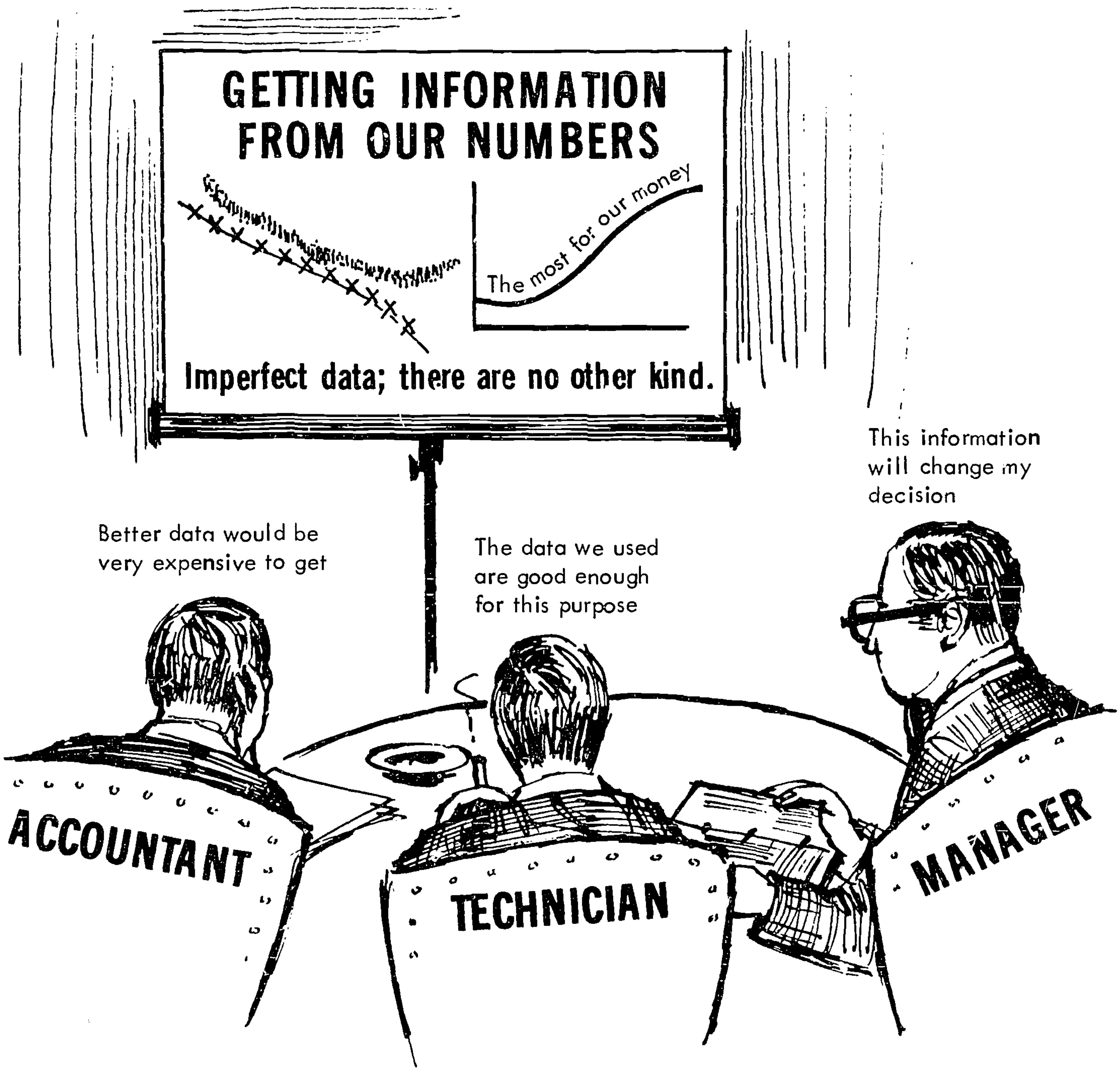


GETTING INFORMATION FROM OUR NUMBERS
The most for our money
Imperfect data; there are no other kind.
Better data would be very expensive to get
The data we used are good enough for this purpose
This information will change my decision
ACCOUNTANT
TECHNICIAN
MANAGER

6. Getting Information From Our Numbers

Cost and output data are useful to resource managers primarily because they make possible meaningful comparisons. The basic unit of comparison is the individual cost/output observation. Each observation relates a specific accomplishment to the specific resources used in achieving it.

With such observations a manager can compare (or anticipate) costs at different *levels* of output or for different *qualities* of output; he can compare (or anticipate) the results of combining resources in alternative ways or of assigning workload among several facilities in alternative ways; he can compare *actual* performance with *expected* performance; he can anticipate the impact of proposed changes: the *added* cost of additional units or of setting higher quality specifications; the savings that might be realized through a cutback. In short, he can use these comparisons either to bring his budget realistically into line with his objectives or to tailor his objectives until they fit his budget, or to do some of both.

These uses have been illustrated in the preceding sections by hypothetical examples. The examples yielded precise information because, by definition, the cost/output observations on which they were based by definition, differed from each other in the respect being compared and *only* in that respect. For instance, in plotting a curve which showed the relationship of cost to output over a range of outputs, each point represented output units which were identical *except* for the number of units turned out. In short, the numbers were perfect for the purpose to which they were applied.

"*Of course*," you may be thinking, "I could do a better job of managing resources if I had that sort of accurate cost/output information. But the numbers available for *my* activity do not meet those specifications. Collecting data *that* good would cost more than we could afford, and furthermore, it just could not be done."

Such a reaction might be partly right. Analysis of actual cost and actual output numbers can never result in information as precise as that derived from hypothetical examples. "Real" numbers *will* be imperfect; there are no other kind. But this does not mean that useful comparisons cannot be made with "real" numbers drawn from the records of your own activity. It *does* mean that some rules for living with imperfect numbers must be observed. Data must be scrutinzed carefully, since invalid comparisons are easy to make and may result in misleading conclusions. Moreover, imprecise data has to be interpreted, and this often requires statistical techniques somewhat different from those described earlier.

You are also right to be concerned over the cost of setting up and maintaining records. Collecting better and more precise data than are needed is, itself, a wasteful use of resources. Numbers that were easier to obtain might be precise enough for many analytic uses. In fact, one of the first questions you must face in living with "real" numbers is precisely this: how good is good enough?

The question does not have a single definitive answer. In many cases, the use of "imperfect" numbers for analysis will simply make your conclusions less precise than those in the hypothetical examples presented earlier. But this is not always the case. Numbers may also be defective in ways which would render invalid any conclusions based on them. For purposes of cost/output analysis, it is emphatically *not true* that any numbers are better than no numbers at all.

As a general rule, data are not good enough for analysis *unless the individual observations being compared relate specific accomplishments to the resources actually used in achieving those results*. Records should be set up in such a way as to do this. Costs should be recorded not when resources were ordered, delivered or paid for but when they were *used*. The units in which output is recorded should measure directly what was accomplished and not simply restate in physical terms *an input*, such as man-hours. Both of these requirements were explained in detail in Sections 3 and 4, and if the numbers being collected for your activity do not meet these criteria, they should not be used in the ways described here. Unless such numbers are needed for other purposes, collecting them may be a waste of resources. To build a data base for analysis, record systems should, if necessary, be modified to meet these two conditions.

Assuming that your records *do* satisfy these basic criteria, the numbers will yield valid—though not necessarily precise—conclusions so long as you avoid comparing cost/output observations which are not comparable. Applying this rule is not so simple as it sounds. In the theoretical examples presented earlier, comparable observations were defined as those which differed only in the respect being compared. But if observations had to be identical *except* for selected characteristics, numbers would have to be collected under the conditions of a laboratory experiment (all other variables held constant). "Real" observations—those drawn from operating records—must differ from each other. Each is unique.

Real observations represent work done at different times or different places or both. Entries may have been made in different records—with varying degrees of accuracy—by different clerks. Between one observation and the next, input prices may have changed—selectively or across-the-board. Seasonal or geographic variations may have occurred. The composition of a facility's workload may have changed— temporarily or permanently. Technology may have changed; needs may have changed; the activity's assignment may have been redefined.

In a laboratory environment, *any* of these changes might be sufficient cause for rejecting the observation, but in using real numbers, your task is to distinguish between those which—in the absence of explicit adjustments—would invalidate comparisons and those which merely make them less precise. The distinction is a matter of judgment and, if you are familiar with the circumstances, can usually be settled by common sense.

Suppose your organization has been assigned an additional function for which resources must be used (perhaps a training base is given a direct role in some community activity). If your records simply continue to record output in the old unit (number of recruits graduated), "before" and "after" cost comparisons would be misleading. There are various options for adjusting cost or output records (the most satisfactory solution might be to allocate costs and keep separate records for the two functions), but the important requirement is that you recognize the need for making an adjustment *and do* so.

Often comparability can be restored by adjustments, but you need also be alert to identify permanent changes in the character of your activity. Such changes might preclude entirely certain types of "before" and "after" comparisons. For an aircraft engine rework facility, for instance, the transition from overhauling piston to jet engines might constitute such a decisive discontinuity.

In other cases, comparability may best be served by excluding individual observations. If you identify an "abnormal" cost/output observation as being associated with some temporary factor (a flood, say, or a transportation stoppage), you might exclude it from comparisons. You might also exclude individual observations where the accuracy of reporting seemed seriously suspect.

More general adjustments may also be required. Cost/output observations made over a considerable period of time should not be compared without taking the impact of sustained inflation into account. Appropriate adjustment factors might be applied to cost data and thus built directly into the statistical analysis; in other cases, [illegible] may be enough for you—as the user of the a[illegible]sis—to be aware of inflation and allow [illegible] in interpreting the results. Allowing for [illegible]art of your job as a manager. There are [illegible]andard techniques for comparing monthly data in an activity where operations are subject to measurable seasonal fluctuations. As noted earlier, comparisons between investment projects which differ in extent of capital investment and useful life require application of a discounting technique to measure the present value of both.

But comparability among cost/output observations cannot be assured simply by adhering to standard statistical procedures, or by applying standard criteria. Consider the apparently obvious requirement that "comparable" cost/output observations should include the same component elements of cost. This would usually be true, but as the example of choosing between two aircraft types to transport specified cargo (Section 5) showed, there are times when one alternative should allow for acquisition costs and the other should not.

Decisions to adjust certain observations or exclude others from analysis always require personal familiarity with the data being collected, the activity being analyzed and the purpose for which the analysis is being made. This process of "cleaning up the data" is itself an essential part of analysis.

But "clean" numbers will still be *imperfect* numbers, because they are subject to a wide range of unpredictable and unsystematic variations. These variations do not render comparisons invalid, but they may make such comparisons very hard to interpret. In order to extract useful information from variable data, you will often need the help of statistical techniques designed for that purpose. These too are part of the process of "living with imperfect numbers."

Unless you are engaged in a very simple, routine operation, the units included in your output records will not be completely uniform. At different times or in different places the same number of units will represent differing accomplishments which embody differing amounts of work. For instance, the output unit most commonly used for freight transportation is the ton/mile. But one hundred ton/miles might equally well represent the movement of one ton of freight for 100 miles or the movement of 100 tons for one mile. Although these two outputs would appear the same in the records, the amounts of travel and handling would be very different, and their cost almost certainly would not be the same. Similar variations occur for measures which might be applied in almost every type of activity: patient days in a hospital, personnel actions processed, experiments conducted, contracts negotiated, orders filled.

Let us consider this problem in terms of an extreme example. Suppose you were in charge of the automotive repair shop discussed in Section 5 and were seeking a unit of output measurement. Over the course of a typical week, the shop's workload might run the gamut from replacing sparkplugs to major engine repairs. Choosing an output measure for such a facility presents serious problems. If each completed job were counted as a unit of output, it would seem that the disparities among observations must make analysis meaningless. But alternative solutions would also pose difficulties.

One alternative might be to segregate various categories of repair work and maintain separate cost and output records for each. This procedure would entail complex cost allocations among categories. Record keeping would become expensive—perhaps prohibitively so.

Another approach might entail creating an abstract output unit to provide a common denominator for diverse repair jobs. These could then be assigned differing values (1-unit, 3-unit, or 10-unit jobs). Even if engineering studies or other objective criteria were used in evaluating specific "jobs," output measurement would risk becoming a disguised restatement of one or more inputs. A sophisticated unit of measurement would be more ambiguous to define; it would also be more expensive to collect than a simple tally of completed repair jobs and more subject to reporting error.

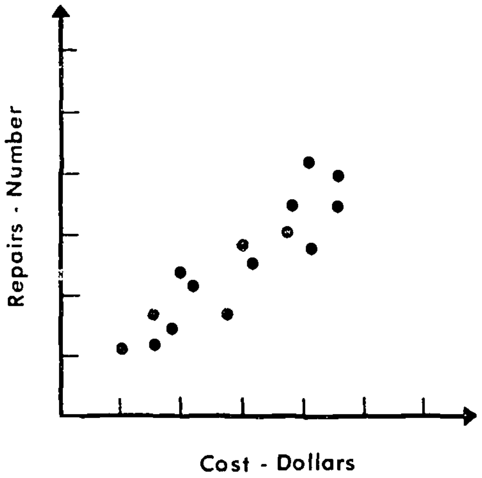
As a practical matter, managers may often find that they will not have cost and output records available for analysis *unless* they are able to develop meaningful information out of variable data. And even with a measure like "jobs completed" at an automotive repair facility, this might be done. In the first place, lengthening the time period covered by each cost/output observation should greatly reduce the disparity among them. Jobs completed per day, per week or per month would become increasingly likely to encompass a typical selection of major and minor repairs. And the longer the time period chosen, the greater the probability that most observations would represent a similar "mix."

Nevertheless, this "mix" would never be identical; most periods would deviate somewhat from the average and some, almost certainly, would deviate a great deal. So long as these deviations did not reflect a major and enduring change in the character of repair procedures (such as a decision to substitute replacement parts and ship the originals off for overhaul instead of doing repairs on the premises), they would not destroy the validity of comparisons among cost/output observations.

But even if comparisons were *valid*, would they also be *useful*? Weekly costs might differ for a dozen reasons related to the nature of the jobs done rather than the weekly number of output units. How could you discover what differences in costs *were* attributable specifically to disparities in output level?

Certainly if you plotted individual observations on a graph like those illustrated in Section 2, (see p. 21) with output measured along one axis and associated costs on the other, these observations would not form a line or curve as did those shown in the examples. Instead you would find yourself looking at a "scatter diagram" like that in Figure 1. You might have to examine the diagram rather closely to recognize that higher expenditures and higher output

Figure 1



levels *did* in fact tend—at least very roughly—to be associated.

While a positive relationship between cost and output levels could thus be identified by inspection, the information—scarcely surprising—would not be precise enough to help in decision making. Is there any way in which you could make it so? You might, if your observations were so positioned that they formed a distinct band, enclose the band with two lines and thus establish the probable range of costs to be expected at each output level (Figure 2). By doing this you would also identify any observations notably outside the band and might earmark these for investigation.

But this very elementary analysis would still fall far short of the use you could make of a line (or curve) from which you could read directly the aggregate cost to be expected at any selected level of output. Such a line (or curve) would be even more useful if you also knew how close most weekly observations could be expected to lie to the estimated values and how often the costs for individual weeks might be expected to deviate by more than some specified amount. By applying appropriate statistical techniques, variable cost/output data often can be made to yield just this information.

Suppose you took a ruler and drew a straight line lengthwise through the scatter of cost/output points (Figure 3). If the visual "fit" of this line were good, i.e. if the observations above and below seemed to be about equal in number and distance from the line, you might use it as an estimating tool in budgeting for expected workloads or in calculating the probable impact on costs of workload changes. Depending on how good the fit appeared to be and how you intended using the estimates, this visually drawn "regression line" might meet your analytic needs.

But greater precision could be obtained by fitting a linear regression line statistically. Such a line is based on an equation derived from the

Figure 2

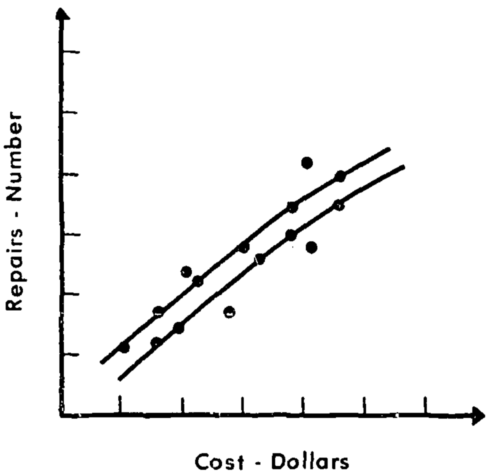
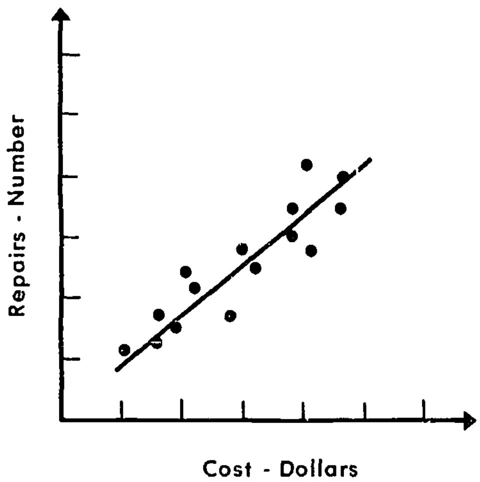


Figure 3



entire range of cost/output observations and is constructed so as to *minimize* the extent to which costs actually reported in the individual observations deviate from those shown by the regression line for appropriate output levels. In addition to fitting a regression line, this estimating equation could be used to identify the operating level at which unit costs would probably be lowest and to compute the "marginal" costs involved in moving from one output level to another.

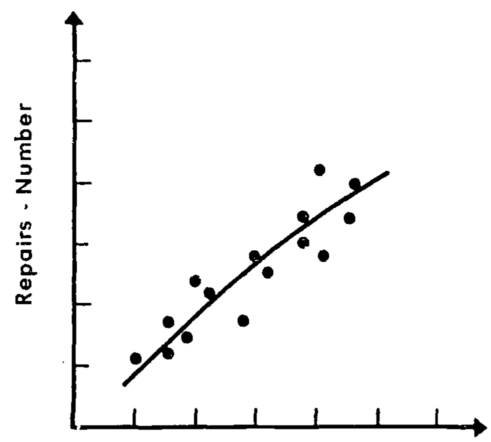
With such an equation it would also become possible to determine mathematically the relative importance of output level (workload) as compared with other variables in accounting for recorded differences in weekly costs. (The closer the relationship between costs and output level, of course, the greater the predictive value of the regression line.) If a sufficient number of weekly observations were available, it would also be possible to compute measures of deviation and establish a dollar range above or below the estimated cost within which most weekly observations would be expected to fall.

These computations are not difficult and can be performed by any statistician. If you would like to fit a regression line to data yourself, you can readily find the techniques in elementary statistics texts.

It may turn out, however, that a straight line does not provide the best description of your data. In fact, a reexamination of the "scatter diagram" suggests that a curve like that fitted visually in Figure 4 would give a better representation of the apparent relationship between the weekly number of repair jobs and their aggregate cost. In moving from very low operating levels to somewhat higher ones, costs seem to rise very modestly compared with the increase in work completed. But at heavier workloads, the cost of turning out additional jobs per week climbs more rapidly.

This type of curve (a parabola—or more properly a segment of one) can also be fitted mathematically to a scatter diagram of cost/output observations, and statistical tests similar to those used for a linear regression equation would show whether a line or a curve describes better the relationship of cost to output for a particular activity (i.e., provides a better "fit" for the data). The equation required to fit a curve of this sort is somewhat more complex than that used for a linear regression. But it too

Figure 4



is a standard statistical procedure, described in elementary texts, and one which any statistician can readily perform unless you choose to make your own computations.

Which equation would provide a better fit for data drawn from *your* activity would depend on several factors. As the hypothetical examples suggested, data collected over a wide *enough* range of outputs would reveal a cost/output relationship in the form of a curve. Starting from very low output levels, a large increase in work completed by a facility of a given physical capacity could be achieved with a modest increase in expenditures. Beyond some point, however, additional increases in jobs completed would become increasingly expensive and eventually prohibitively so. In theory at least, there would eventually be a point beyond which trying to increase the number of jobs would so clog the system as to actually *reduce* the number completed within the week.

Observations drawn from actual operating experience, of course, would rarely if ever encompass this entire range. And it is quite possible that the segment of the range covered by your operating data could be described most simply by a straight line. In either case, "real" and imperfect numbers will yield valuable information for analysis if we use elementary statistics to make sense out of scatter diagrams.

Both the benefits and pitfalls of using "real" numbers for analysis can be illustrated by a case history involving data taken from actual operating records and put to actual analytic uses. The numbers in the following example were collected by 13 food service centers and related the number of meals served at each center over the course of a fiscal year to the non-food costs of serving them. The first objective of analysis was to determine what relationship existed between facility size (annual volume of meal service) and serving costs. Factors which might obscure that relationship (i.e., cause individual observations to "scatter" around a regression line) included the likelihood that the 13 facilities differed in many respects other than size and that records might be kept differently at different locations.

Analytic uses to be made of the cost/output relationship—once established through a regression line— included performance evaluation (comparing the operating efficiency of individual food centers) and long-range planning (cost considerations in decisions to centralize or decentralize food service) as well as the obvious one of estimating budget needs for various facilities on the basis of their expected service loads.

Table 1

FOOD SERVICES - FY 1969

(Excluding Cost of Food)

(13 Locations)

(1) Meals Served	Actual Expenses (2) Total Dollars	(3) $ Per Meal
23,766	83,600	3.52
212,581	265,600	1.25
245,827	244,600	1.00
255,557	204,200	.80
277,858	164,300	.59
302,153	197,200	.65
339,597	212,900	.63
464,932	258,400	.56
3,824,230	1,249,000	.33
5,045,711	1,304,700	.26
6,563,607	2,033,200	.31
7,432,668	1,610,100	.22
20,596,557	4,539,300	.22

In Table 1, the figures collected from the 13 locations have been arranged in ascending order of magnitude according to the number of meals served annually at each location. Column 2 gives aggregate serving costs at each location, while serving costs per meal have been computed in Column 3. One important analytic conclusion could be read directly from that column: feeding large numbers of people at a single location evidently permitted notable savings in the cost of providing service.

Figure 5

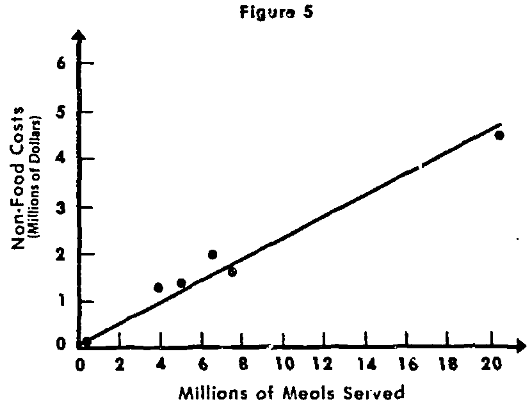


Figure 5 graphically confirmed that conclusion. Only six points were plotted on the graph because the wide spread among annual service loads—ranging up to 20 million meals—necessitated a grid on which observations for all eight locations serving fewer than 500,000 meals were represented by a single dot. But the linear regression line describing the relationship of the scattered points was "fitted" by an equation derived from all 13 observations.

This equation appeared to establish two conclusions: first, the slope of the regression line showed that, as meal volume increased, serving costs rose much less than proportionately, and second the line itself provided a very good "fit" for the observations. Statistical tests indicated that 98 percent of all cost variations among the 13 locations could be accounted for by their differences in meal volume.

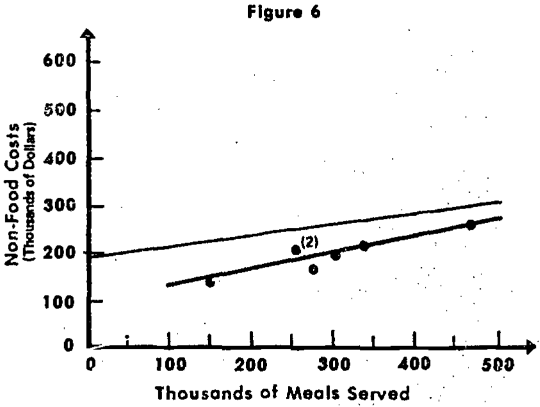
This high correlation seemed to clear the way for putting the regression line and the equation on which it was based to all the analytic uses mentioned above: budget estimation for facilities of all sizes throughout the range, long-range planning and performance evaluation. But a substantial number of management decisions involved facilities serving fewer than 500,000 meals annually, and these observations could not be identified separately on the grid used in Figure 5. Consequently that portion of the graph was expanded and the individual observations for these facilities were replotted on a greatly enlarged grid.

When this was done, it immediately became apparent that deviations from the regression line among these smaller facilities were very significant *relative to their own level of operations.* The absolute dollar amounts of deviation were too small to affect correlation tests because the aggregates were dominated by facilities serving millions of meals annually. Routine application of standard statistical procedures had obscured the fact that facilities operating at such widely disparate levels might not be really comparable. A separate regression line, fitted to facilities in the 100,000 to 500,000 meal range, seemed likely to provide better information for those concerned with their management.

Furthermore, in fitting the original regression line, data from all 13 locations had been accepted uncritically. Now the accuracy of those observations which were furthest "out-of-line" was called into question. Review of the suspect numbers revealed that data reported for the smallest food service location were unusable, and that observations for several others were not comparable as reported.

After adjusting for these discrepancies, revised cost/output observations representing seven facilities in the 100,000 to 500,000 meal range were plotted in Figure 6. The revised regression line fitted to these points is shown as a heavy line. Drawn more lightly is the old regression line based on uncorrected data supplied by 13 facilities of all sizes. The two lines differ as a result both of reexamining the raw data (cleaning up the numbers) and of limiting coverage to the "under 500,000" size range.

Figure 6



How significant to decision makers would these revisions be? Note first that none of the changes in any way challenged the main conclusion to be drawn from Table 1 and Figure 5—that notable economies in serving costs could be achieved by concentrating all food service at facilities providing five million meals or more per year. But considerations of geography and transportation would almost certainly rule out this solution. Realistically therefore, facilities in the smaller size ranges would remain, and managers seeking to make the best possible decisions would be better served by using the revised regression line in Figure 6 and its underlying equation.

The value of using "clean" and comparable data for budget estimates can be demonstrated quantitatively from Table 2. The original regression equation would have yielded the cost estimates for five selected service levels shown in Column 2. The revised equation provided the lower estimates in Column 3. Reliance on the original equation would have resulted in unnecessarily high budget requests at all five levels, and especially at the smaller facilities.

Table 2

ESTIMATED FOOD SERVICE COSTS - FY 1969

(Excluding Cost of Food)

(1) Number of Meals	(2) Old Equation	(3) New Equation	(4) Difference
100,000	214,000	120,000	94,000
200,000	236,000	160,000	76,000
300,000	258,000	198,000	60,000
400,000	280,000	236,000	44,000
600,000	300,000	276,000	26,000

Next, suppose both sets of estimates were being used to help develop long-range plans for the size and location of food service centers. Analysis of either set would indicate that operating savings could be achieved by serving larger numbers of meals at fewer locations. But the revised figures would show a smaller saving than the original analysis. Suppose a total of 500,000 meals were to be provided annually. If two locations were set up—one providing 200,000 meals and the other 300,000—the estimated annual serving costs at the combined locations would, according to the old equation, amount to $494,000 ($236,000 at the first and $258,000 at the second). If instead, the entire 500,000 meals were served at a single location, total non-food expenses would be only $300,000—an indicated saving through consolidation of $194,000. Revised estimates would indicate a potential saving of $83,000—less than half as great.

Since either analysis would have predicted savings through consolidation, the differences in amount might seem unimportant. But direct operating expenses are not the only criterion in deciding the size and location of facilities. Factors such as capital expenditures, quality of service, convenience to diners, time and transportation to and from meals, etc. might favor smaller, more conveniently located facilities. In weighing proposals to consolidate, the undisputed *fact* of some cost differential in favor of larger service units might be less important than its probable *size*.

Either regression line could be used by managers to identify those facilities which were "out-of-line"—where the cost of serving meals was notably above or below what might have been expected solely on the basis of size. By screening out the effect of size difference on costs, the line would make possible direct comparisons among individual facilities. For these comparisons to be significant, the line must be based on observations which were accurate and suitable for comparison. In our example, the revised regression line would clearly be more reliable on both counts as a basis for judging relative performance. The comparisons themselves would not constitute performance evaluation, but only its first stage. The real challenge to management would lie in identifying (and if possible correcting) the specific problems which accounted for unexpectedly high expenses at some locations and—perhaps even more importantly—in identifying (and if possible adopting elsewhere) the conditions or methods that produced superior performances.

Like an X-ray camera, the statistical technique of regression analysis has the ability to "see through" a scatter of individual observations to an underlying bone structure—their measurable cost/output relationship. And this relationship is the basis for most of the analysis discussed in the preceding sections. In order to obtain valuable information for decision making from "real" numbers, you need only make sure that two prior conditions are met: your records must be kept on a basis permitting valid cost/output observations, and the data must be "clean"—individual observations must be accurate and comparable for the purpose at hand. These conditions apply whether the management function involves research projects, inventory control, capital goods acquisition or the operation of facilities such as food service centers discussed here.

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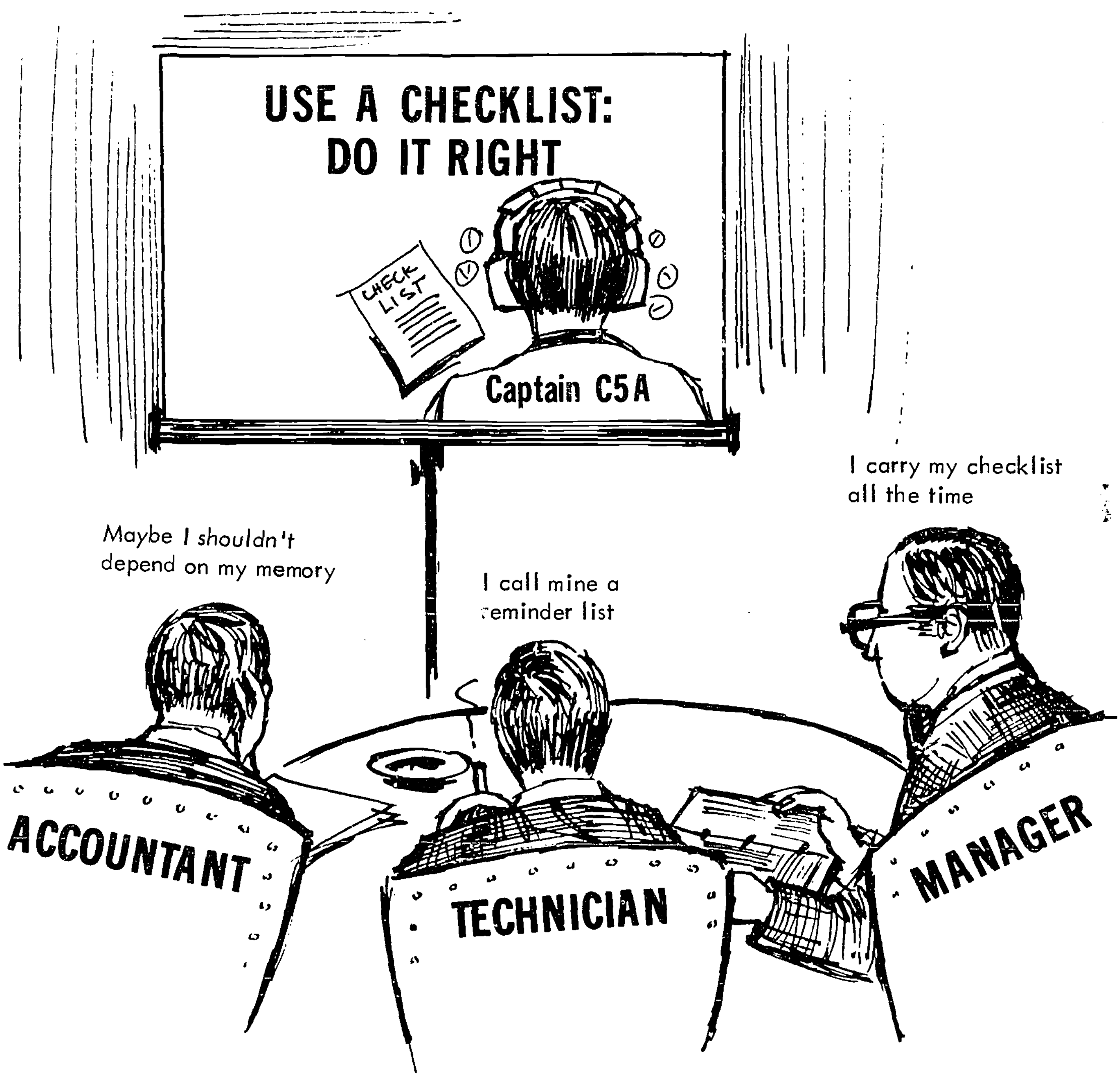

USE A CHECKLIST:
DO IT RIGHT
CHECK LIST
Captain C5A
Maybe I shouldn't depend on my memory
I call mine a reminder list
I carry my checklist all the time
ACCOUNTANT
TECHNICIAN
MANAGER

7. Use a Checklist; Do It Right

Analysis cannot help you in your job as a decision maker unless you have the right numbers available in the right places at the right time. You cannot wait until you are confronted with a deadline to decide what numbers you need for analysis and then collect them. Analysis depends on an adequate data base—one which can be built only by setting up appropriate cost and output records and maintaining them over time.

Moreover, since "real" numbers will never be perfect, it is highly important for you and other users of these data to know how the records are collected and precisely what they contain.

If you have read this far, you have encountered a number of criteria for maintaining records which *will* provide the right numbers at the right time. You probably have most of them in mind. But in the same way that airline pilots use a checklist to make sure that all essential tasks have been completed every time they take off or land, you may find the following list a useful reminder. There is no single "right" answer to any of the questions on this list, but each raises a point you need to consider in the light of your own circumstances.

I. CHECKLIST FOR ESTABLISHING A DATA BASE

A. What *Uses* for Cost and Output Data:

1. Who will use these data? You? Your superiors? Someone working for you? All of these?

2. What will these data be used for: Improving control of day-to-day operations? Preparing budgets? Evaluating performance? Justifying future budget proposals? Long-range planning?

3. At what *level* will decisions based on these numbers be made? What sort of choices will be open to the decision maker: To make the best use of his present budget? To achieve his mission at the lowest cost? To acquire new facilities or dispose of old ones? To change quality specifications? To seek new solutions for broad problems?

4. If these data are limited or imprecise, for what levels of analysis and decision making *can* they appropriately be used?

5. How promptly will users of these data need current numbers? Will someone still be revising and analyzing numbers after the deadline for decision is past?

6. What format for presenting these data will be most helpful to major users?

7. Will numbers collected for this activity be compared with those for other facilities? Are they comparable? Is the same format used for each?

8. Do those actually engaged in collecting and tabulating the data have clear instructions as to what numbers to collect and how these should be combined or displayed? Do they have guidelines for identifying numbers which fall outside some expected size range? Are they expected to double-check such numbers for reporting accuracy?

B. What *Costs* to Count:

1. Can costs be matched to output for the same time periods? Do cost figures cover the resources, and only the resources, actually *used* in that time period?

2. Can users identify and use separately those cost items which are relevant to their decision or level of analysis? If costs over which you do not have direct control are excluded from your data, are these items available separately for decisions to which they are relevant? Are operating costs and capital costs separately identified?

3. Can costs associated with partially completed output units be excluded from analysis?

4. If your activity has several functions, how are cost items allocated among them?

C. What *Output* to Measure:

1. Does your activity have a clear and explicit statement of objectives? Is it written in quantifiable terms?

2. Does your activity have a clearly identifiable end product or service?

3. Is this end product or service defined by a set of standards or specifications which can be used as a measure of quality level? Are routine tests or quality control procedures used to determine how consistently output meets these standards?

4. Does your unit of measurement really represent *output* or does it simply restate an input in physical terms?

5. Do your output units measure all the output and only the output covered by your cost data? Do the numbers include only completed units? What adjustments do you make for partially completed units?

6. If your activity has more than one end product or service, should these be consolidated in a single measure? Or should costs be allocated among several types of output? How?

II. CHECKLIST FOR MAINTAINING A DATA BASE

A. What *Changes* to Adjust for:

1. Has your activity's mission changed or have its objectives been redefined? Is the existing output measure still appropriate?

2. Have new functions been added? Are they covered by your present output unit? Are they part of your costs? Should an additional measure of output be set up and costs allocated among several functions?

3. Are quality standards for your activity subject to review and change? If they have been changed, do output units reflect these changes?

4. Should comparisons of cost data over time include an adjustment for price level changes?

5. Have there been significant technological changes in your activity? Do these affect the comparability of cost data over time? Are there adjustments which can restore comparability?

B. What *Numbers* to Collect:

1. Are existing cost and output data for your activity reviewed periodically to determine what uses are being made of them? If they are not being used, why? If they are no longer *useful*, can you stop collecting them?

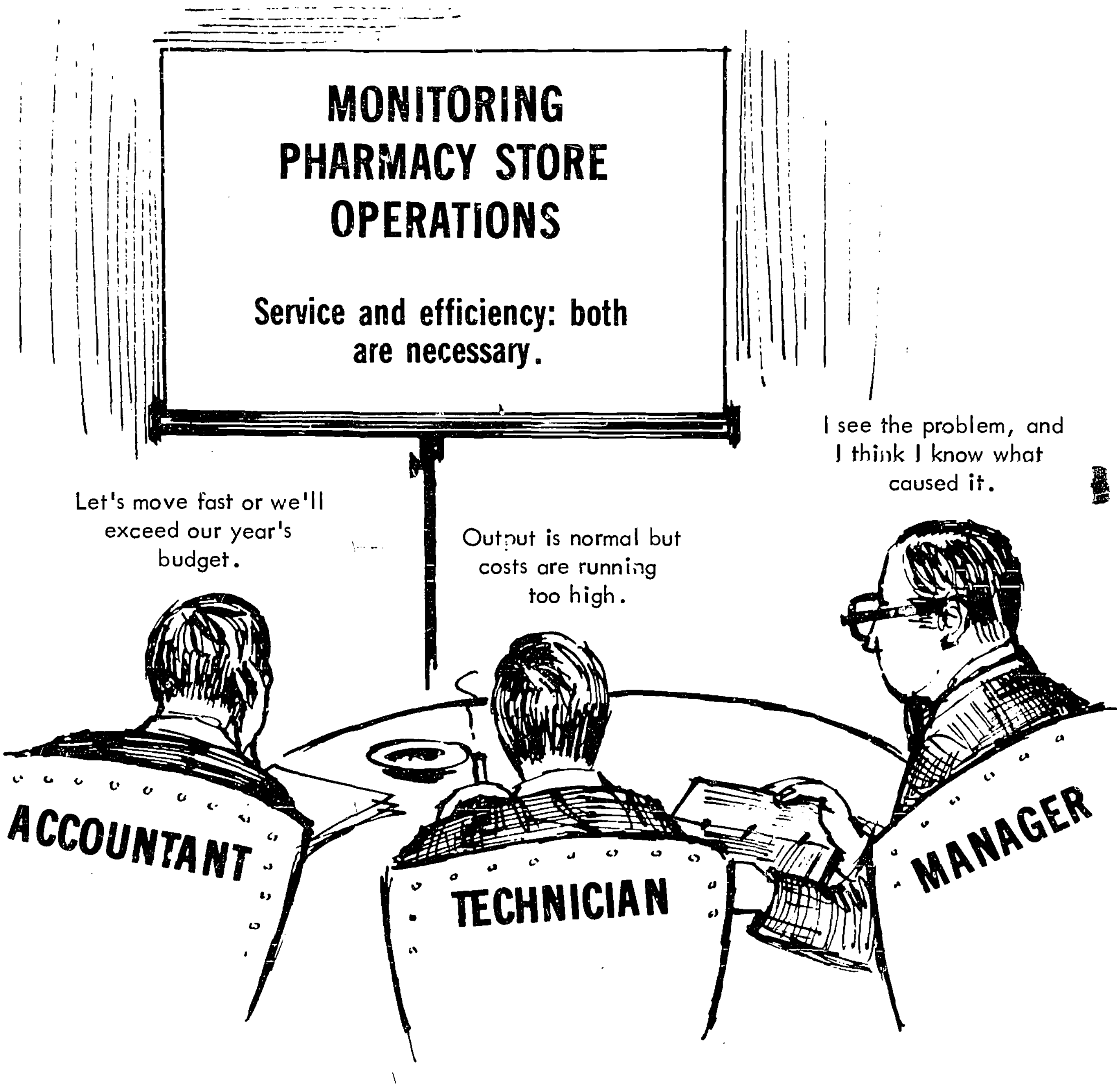
2. If numbers are being collected for others, are they still being used? If not, are they worth collecting for your own use? If not, can you stop collecting them?

3. Could you make more use of cost and output data if they were modified? How much would the modifications cost? Would they be worth making?

If these are your data—collected for an activity you understand and under circumstances with which you are familiar, you may be like the airline pilot: you would almost certainly take account of all the points raised by these questions without the checklist. Taking account of them is part of your job. But competent and experienced pilots still use checklists. Faithfully using the checklist is insurance against some day making a crash landing.

PART III
SOME USES OF ANALYSIS: CASE HISTORIES

III - 1


MONITORING
PHARMACY STORE
OPERATIONS
Service and efficiency: both
are necessary.
I see the problem, and
I think I know what
caused it.
Let's move fast or we'll
exceed our year's
budget.
Output is normal but
costs are running
too high.
ACCOUNTANT
TECHNICIAN
MANAGER

CASE HISTORY 1: MONITORING PHARMACY STORE OPERATIONS

The situation. In August 1966 when the Department of Defense issued Directive 7000.1 providing for the design and installation of Resource Management Systems, it required—among other things—that such systems be established for *operating activities* and specified that these systems should provide a means of matching cost and output data which would: "1) Focus on outputs and on resources used, i.e. expenses, 2) Focus on managers who are responsible for effective and efficient utilization of resources and 3) Focus on actual performance in relation to planned performance . . . . ."

A fifteen base training complex for one Service undertook to comply with this directive by choosing output measures for various operating activities and testing these measures over a period of time. When this had been accomplished for several activities, the Resource Management Center for the complex moved on to the next phase of its program by adopting a uniform reporting format and requiring monthly cost

Table 1

PHARMACY SERVICE: BASE W

Prescriptions Filled

		ITEM		JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE
OUTPUT-PRESCRIPTIONS FILLED (NUMBER)	MONTHLY	PLAN	01	4866	4520	4051	4780	4920	4315	6391	4840	4775	4790	5010	4650
		ACTUAL	02	4866											
		VARIANCE (02–01)	03	--											
		% OF PLAN (02 ÷ 01)	04	100											
	CUMULATIVE	PLAN (CUM 01)	05	4866	9386	13437	18217	23137	27452	33843	38683	43458	48248	53258	57908
		ACTUAL (CUM 02)	06	4866											
		VARIANCE (06–05)	07	--											
		% OF PLAN (06 ÷ 05)	08	100											
COST (THOUSANDS OF DOLLARS)	MONTHLY	PLAN	09	5.8	5.8	5.9	6.4	6.4	6.4	7.3	7.2	7.2	6.1	6.0	6.0
		ACTUAL	10	5.5											
		VARIANCE (10–09)	11	–0.3											
		% OF PLAN (10 ÷ 09)	12	95											
	CUMULATIVE	PLAN (CUM 09)	13	5.8	11.6	17.5	23.9	30.3	36.7	44.0	51.2	58.4	64.5	70.5	76.5
		ACTUAL (CUM 10)	14	5.5											
		VARIANCE (14–13)	15	–.3											
		% OF PLAN (14 ÷ 13)	16	95											
COST PER PRESCRIPTION FILLED (CENTS)	MONTHLY	PLAN (09 ÷ 01)	17	119	128	146	134	130	148	114	149	151	127	120	129
		ACTUAL (10 ÷ 02)	18	113											
		VARIANCE (18–17)	19	–6											
		% OF PLAN (18 ÷ 17)	20	95											
	CUMULATIVE	PLAN (13 ÷ 05)	21	119	124	130	131	131	134	130	132	134	134	132	132
		ACTUAL (14 ÷ 06)	22	113											
		VARIANCE (22–21)	23	–6											
		% OF PLAN (22 ÷ 21)	24	95											

and output reports for these activities from each of the fifteen bases.

At the time this requirement went into effect, Colonel Albert was commander at Base W—one of those in the training complex. Regular reporting began in July with the start of a new fiscal year. The following month, copies of the initial reports for activities with established output measures appeared on his desk.

Colonel Albert was not aware of any immediate operating problems which required his attention in any of the areas involved. In the preceding fiscal year, however, costs for operating *pharmacy services*, which was the subject of one of these reports, had exceeded the amount budgeted making it necessary to obtain additional funds. Remembering this, he picked out the report for the base pharmacy for a closer look.

The Numbers. The summary which Colonel Albert examined (Table 1) provided separate panels for, 1) output—prescriptions filled by the pharmacy service at Base W; 2) expenses—including the cost of drugs, in thousands of dollars; and 3) cost per prescription in cents. He saw that the reporting format had been designed to permit a variety of comparisons—from one month to another or between planned and actual performance—and also to relate cost and output through the unit cost panel. Planned levels for output, costs and unit costs over the entire fiscal year had already been entered in the table on both a monthly and a cumulative basis. There were also slots for computing the amount and per cent by which actual numbers deviated each month—and cumulatively—from these expected magnitudes.

In view of the earlier problem caused when pharmacy expenditures had exceeded the budget, Colonel Albert noted with satisfaction that actual July expenses were now somewhat below the amount currently projected. He had been hearing considerable grumbling about output measurement and the added work these reports would cause, but now he found himself thinking how useful this type of information on pharmacy operations would have been the previous year. Regular reporting might not have prevented the need for additional funds, but at least the developing problem would have become apparent much sooner.

Indeed, it occurred to Colonel Albert that the filling of prescriptions was an activity where timely reports which compared actual with expected developments would have been *especially* valuable. The pharmacy manager had probably been aware over the course of the year how high his expenditures were running. But he had no responsibility for the issuance of prescriptions to be filled and thus had little influence on the cost of drugs—the most important element in his costs. If the Surgeon General who *did* have that responsibility had been receiving a report like this on the new form, he too would have been alerted to the developing excess of actual over expected expenditures. He could have determined whether the trend was due to unavoidable circumstances, such as increased population on base or an epidemic, or to mismanagement which could be corrected. Either way, reports on the new format would have served as an early indicator of developing needs.

Obtaining Information from the Numbers. Two months passed before the monthly table on pharmacy costs and output again came to Colonel Albert's attention, and on this occasion the numbers were not to his liking. (Table 2.) The first figure which caught his eye was the steep increase to $2.03 in the cost of each prescription filled. Looking up at the cost panel, he saw that monthly costs of $9.9 thousand for September had been 68 per cent above the expected level—a discrepancy far greater than the moderate variance in number of prescriptions filled. In fact, the September cost figure seemed so far out of line that he wondered if a reporting error had not occurred. Accordingly, he called Mr. Zenger, the analyst who coordinated Base W's reporting program.

Mr. Zenger, it turned out, had also been surprised at the September cost entry and had checked it out with the pharmacy manager. The figure, he reported, was correct. "But," Zenger added, "the extra money apparently went into building up the pharmacy's inventory of drugs."

"Hold on a minute," said Albert, "do you mean these monthly cost figures aren't associated with prescriptions filled the same month?"

"Not necessarily. Supplies are entered as costs when they are delivered from the stock fund not when they are used to fill prescriptions."

"Why?"

"Because, as a practical matter, that's the only point at which cost records can be maintained easily and accurately for this activity." Zenger

Table 2
PHARMACY SERVICE: BASE W

Prescriptions Filled

ITEM				JULY	AUG	SEPT	OCT	NOV	DEC
OUTPUT-PRESCRIPTIONS FILLED (NUMBER)	MONTHLY	PLAN	01	4866	4520	4051	4780	4920	4315
		ACTUAL	02	4866	4372	4873			
		VARIANCE (02–01)	03	--	–148	822			
		% OF PLAN (02 ÷ 01)	04	100	97	120			
	CUMULATIVE	PLAN (CUM 01)	05	4866	9386	13437	18217	23137	27452
		ACTUAL (CUM 02)	06	4866	9386	14111			
		VARIANCE (06–05)	07	--	–148	674			
		% OF PLAN (06 ÷ 05)	08	100	98	105			
COST (THOUSANDS OF DOLLARS)	MONTHLY	PLAN	09	5.8	5.8	5.9	6.4	6.4	6.4
		ACTUAL	10	5.5	7.1	9.9			
		VARIANCE (10–09)	11	–0.3	1.3	4.0			
		% OF PLAN (10 ÷ 09)	12	95	122	168			
	CUMULATIVE	PLAN (CUM 09)	13	5.8	11.6	17.5	23.9	30.3	36.7
		ACTUAL (CUM 10)	14	5.5	12.6	22.5			
		VARIANCE (14–13)	15	–.3	1.0	5.0			
		% OF PLAN (14 ÷ 13)	16	95	109	129			
COST PER PRESCRIPTION FILLED (CENTS)	MONTHLY	PLAN (09 ÷ 01)	17	119	128	146	134	130	148
		ACTUAL (10 ÷ 02)	18	113	162	203			
		VARIANCE (18–17)	19	–6	34	57			
		% OF PLAN (18 ÷ 17)	20	95	127	139			
	CUMULATIVE	PLAN (13 ÷ 05)	21	119	124	130	131	131	134
		ACTUAL (14 ÷ 06)	22	113	136	159			
		VARIANCE (22–21)	23	–6	12	29			
		% OF PLAN (22 ÷ 21)	24	95	110	122			

paused and added, "Of course it makes the data less satisfactory. We can't rely on monthly unit cost figures for analysis, for instance, because the cost of drugs in a particular month may not match prescriptions actually filled in that month."

Albert exploded. "So you fellows put out a table that simply does not mean what it says! What good are these data? How can they be *used*?"

"With caution," Zenger answered and then explained. "They can be used the way you just did—to question any number that looks out of line. An inventory build-up may explain *this* number *this* month, but somebody needs to notice and check the explanation. Furthermore, the pharmacist can't go on adding to inventories *every* month—or go on drawing them down every month for that matter. We may not be able to rely on the cost/output relationship for any *particular* month, but over a longer period that sort of thing has to even out."

"Then I *can* use the cumulative comparisons to spot a trend."

"Certainly—but again with caution."

Turning back to Table 2, Colonel Albert saw that the August numbers had also been "out of line" with costs running higher and service volume below expectations. For the three months already recorded on a cumulative basis, costs had outrun expectations by 29 per cent whereas output (prescriptions filled) had exceeded the planned level by only 5 per cent. Given the limitations of his data, this was not conclusive proof that an adverse trend was developing, but the situation definitely bore watching.

October data (see Table 3) showed a continuation of this apparent trend with monthly expenses outrunning the budget projection by 22 per cent and with *cumulative* costs now 27 per cent above planned outlays for the four month period. Since these new cost overruns could not be explained by increased need for service (cumulative costs per prescription had remained at 122 per cent of expectations for a second month), Colonel Albert got in touch with the Surgeon General.

Use Made of the Information. The Surgeon General was aware of the trend in pharmacy service costs which Mr. Zenger had already called to his attention. He agreed that a situation similar to that encountered last year seemed to be developing again but was reluctant to take any action other than an upward revision in the budget.

Colonel Albert probed further. He found that the existing estimates had incorporated what appeared to be an adequate allowance for increased supply prices. The number of prescriptions filled had outrun expectations somewhat—but not significantly, as they knew from the cost/output report. Nor did general health requirements on the base appear to have changed much since the estimates were made because other hospital-related expenditures were running close to their projected levels.

To Colonel Albert, all this suggested that specific problems existed in pharmacy services which might still be identified and corrected so as to keep annual outlays within or close to the budget. While the Surgeon General was pointing out that necessary services, after all, had to be paid for regardless of cost, Colonel Albert was remembering how a new training project had recently been turned down for lack of funds. "Every time we let necessary services cost more than *necessary*," he snapped, "some worthwhile project gets nickeled and dimed to death."

The two men eventually agreed that cost reductions might be possible in this instance and that the possibility should be explored. They decided that upward budget revisions would be considered only if this effort fell short—or if the total number of prescriptions required rose sharply.

In order to continue monitoring cost/output trends for pharmacy services without being distracted by dubious numbers, Colonel Albert arranged for Mr. Zenger to furnish him a summary table showing only cumulative data by quarters. (Table 4.) Throughout the remainder of the fiscal year, this quarterly summary provided increasingly favorable reading.

Despite flu epidemics in December and March which raised the total number of prescriptions for both the second and the third quarters sharply above the level anticipated earlier, the percentage by which cumulative costs exceeded the planned level steadily declined. By the end of the fiscal year, total expenses for filling 64,000 prescriptions were only 3 per cent above the outlays which had been anticipated for filling less than 58,000. As a result, unit costs for the full year averaged $1.23—7 per cent below the

Table 3
PHARMACY SERVICE: BASE W

Prescriptions Filled

ITEM				JULY	AUG	SEPT	OCT	NOV	DEC
OUTPUT-PRESCRIPTIONS FILLED (NUMBER)	MONTHLY	PLAN	01	4866	4520	4051	4780	4920	4315
		ACTUAL	02	4866	4372	4873	4861		
		VARIANCE (02–01)	03	--	–148	822	81		
		% OF PLAN (02 ÷ 01)	04	100	97	120	102		
	CUMULATIVE	PLAN (CUM 01)	05	4866	9386	13437	18217	23137	27452
		ACTUAL (CUM 02)	06	4866	9238	14111	18972		
		VARIANCE (06–05)	07	--	–148	674	755		
		% OF PLAN (06 ÷ 05)	08	100	98	105	104		
COST (THOUSANDS OF DOLLARS)	MONTHLY	PLAN	09	5.8	5.8	5.9	6.4	6.4	6.4
		ACTUAL	10	5.5	7.1	9.9	7.8		
		VARIANCE (10–09)	11	–0.3	1.3	4.0	1.4		
		% OF PLAN (10 ÷ 09)	12	95	122	168	122		
	CUMULATIVE	PLAN (CUM 09)	13	5.8	11.6	17.5	23.9	30.3	36.7
		ACTUAL (CUM 10)	14	5.5	12.6	22.5	30.3		
		VARIANCE (14–13)	15	–.3	1.0	5.0	6.4		
		% OF PLAN (14 ÷ 13)	16	95	109	129	127		
COST PER PRESCRIPTION FILLED (CENTS)	MONTHLY	PLAN (09 ÷ 01)	17	119	128	146	134	130	148
		ACTUAL (10 ÷ 02)	18	113	162	203	160		
		VARIANCE (18–17)	19	–6	34	57	26		
		% OF PLAN (18 ÷ 17)	20	95	127	139	119		
	CUMULATIVE	PLAN (13 ÷ 05)	21	119	124	130	131	131	134
		ACTUAL (14 ÷ 06)	22	113	136	159	160		
		VARIANCE (22–21)	23	–6	12	29	29		
		% OF PLAN (22 ÷ 21)	24	95	110	122	122		

Table 4
PHARMACY SERVICE: BASE W

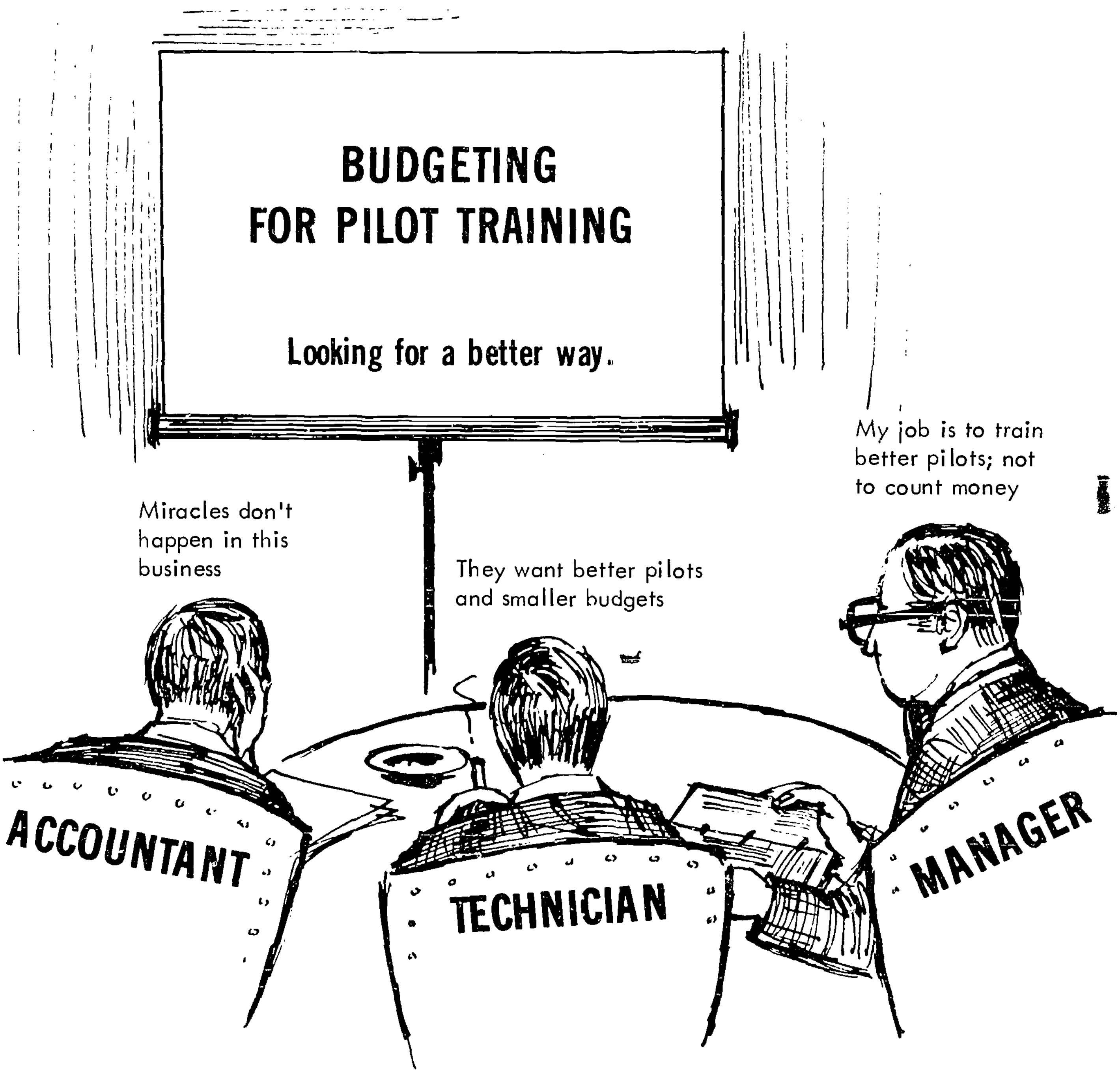
LOCATION:		FISCAL YEAR			
PERIOD:		FIRST QUARTER	SECOND QUARTER	THIRD QUARTER	FOURTH QUARTER
		CUMULATIVE			
OUTPUT - (PRESCRIPTIONS FILLED) (NUMBER)	PLAN	13437	27452	43458	57908
	ACTUAL	14111	29735	48447	64057
	% ACTUAL OF PLAN	105	108	111	111
COST (THOUSANDS OF DOLLARS)	PLAN	17.5	36.7	58.4	76.5
	ACTUAL	22.5	40.8	61.2	78.8
	% ACTUAL OF PLAN	129	111	105	103
COST PER PRESCRIPTION FILLED (CENTS)	PLAN	130	134	134	132
	ACTUAL	159	137	126	123
	% ACTUAL OF PLAN	122	102	94	93

budgeted target of $1.32. This was in contrast to an end-of-September figure 22 per cent *above* the estimate.

The first time he encountered the Surgeon General after receiving this end-of-year report, Colonel Albert warmly congratulated him on these developments and asked what operating problems he had uncovered.

"It's an odd thing," the Surgeon General responded, "there really were none. The chief pharmacist was able to tighten up on some management procedures; inventories were higher than they needed be. But most of the changes were made in my shop—like saving on the cost of unused medicine by filling each prescription with smaller quantities of drugs and then allowing refills. And we issued a formulary to help doctors prescribe less expensive medications when these would be just as effective. But there really was nothing we would have spotted as a *problem* if that damned cost trend hadn't been so highly visible in these new reports."

III – 2


BUDGETING
FOR PILOT TRAINING
Looking for a better way.
Miracles don't happen in this business
They want better pilots and smaller budgets
My job is to train better pilots; not to count money
ACCOUNTANT
TECHNICIAN
MANAGER

CASE HISTORY 2: BUDGETING FOR PILOT TRAINING

The Situation. Admiral Baker is the Operations Officer for a group of nine separate flight training bases. Recently he was informed that the number of student pilots to be trained throughout his command during the next fiscal year would be reduced by 10 percent from the present level and that he should expect a comparable 10 percent cut in his operating budget. He was also informed that the proposed budget reduction was intended to reflect reduced costs associated with the smaller number of trainees rather than any change in the quality of training offered.

Admiral Baker's initial reaction was that a cut of the proposed magnitude would greatly impair the quality of a training program which, in his opinion, was already barely adequate. In fact, he was in the process of preparing a recommendation that the training period be lengthened somewhat to improve pilot familiarity with the increasingly complex equipment they would be operating. Consequently he had requested an interview with the commanding officer and, as a result, found himself preparing for a meeting less than a week away.

He knew he could not make a case for retaining more than 90 percent of his current budget unless he was able to show—convincingly and quantitatively—that costs would *not* decline as much as the student load. He strongly believed they would not do so, but he also realized that neither he nor any of his nine base commanders really knew how costs of flight training throughout the command were related to the number of pilots trained.

The Numbers. Ideally, Admiral Baker would have liked detailed cost records for each of the nine bases which related costs to output *over a range of outputs* and over a considerable period of time. But the only numbers he was able to obtain immediately from his Financial Records Section were those summarized in Table 1. These were annual figures for the preceding fiscal year and showed the number of student weeks of training provided at each of the nine bases along with a dollar figure for operating costs at each base.

The number of student weeks of training provided at the nine bases ranged from slightly more than 8000 at Base A to nearly 13,000 at Base I, with total training carried out at the nine base command averaging out at 10,953 student weeks per base. From the variations in costs reported by these bases, Admiral Baker hoped to identify a general relationship between workload and operating costs—at least over the range of operating levels relevant to the proposed changes in trainee enrollment.

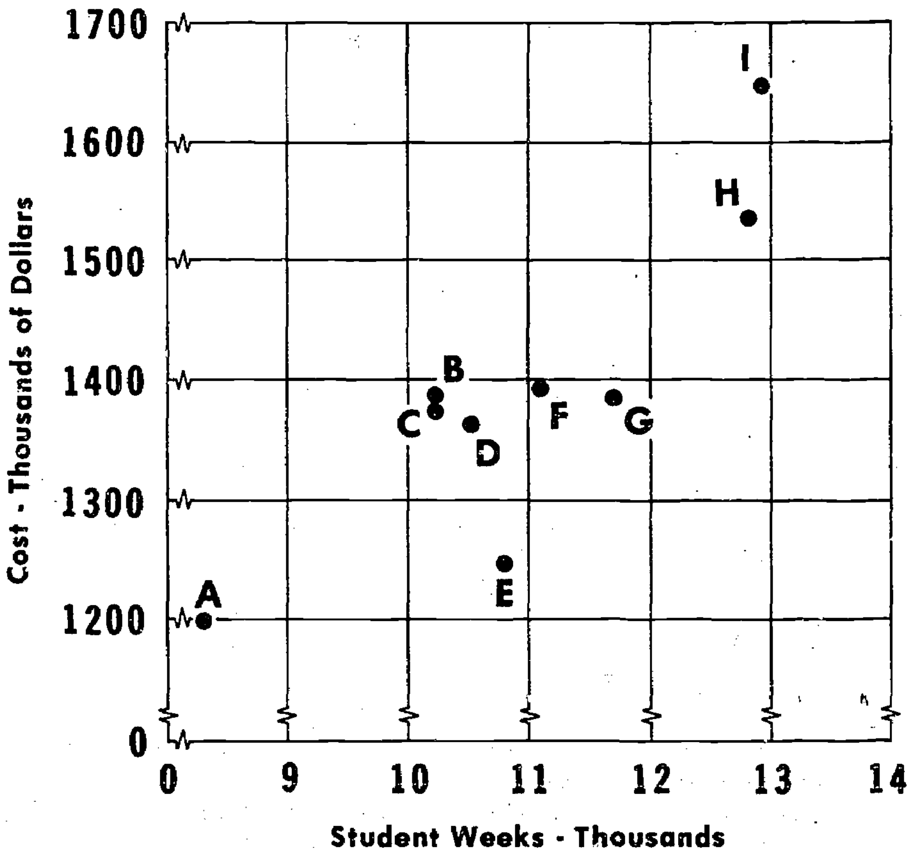
Table 1

Training Base	Number of Student Weeks	Total Cost
A	8,306	$1,199,500
B	10,185	1,387,400
C	10,191	1,377,000
D	10,540	1,362,200
E	10,828	1,246,600
F	11,094	1,392,500
G	11,716	1,383,400
H	12,782	1,534,400
I	12,918	1,646,900

The Analysis. His first step was to construct a chart with dollar costs on the vertical axis and number of student weeks on the horizontal axis and to plot his cost and output numbers for each base on this grid to form a "scatter diagram" like that described in Part II, Section 6, Page 60. He could see from the diagram that bases with larger training loads had generally (though not always) reported higher aggregate operating costs than smaller ones, but whether the differences in costs were more or less than proportional to those in student load was not apparent. (See Figure 1.)

If Admiral Baker had been sure that the cost/output data for each of the bases were complete, accurate and comparable, his next step might have been to fit a "regression line" to these nine points as was explained in Section 6. But Admiral Baker decided he was not ready for this because when he looked carefully at the points he had plotted, he saw that some large cost variations clearly could not be explained by differences in student load. Base E, for instance, had reported operating costs which were much *lower* than those at three bases providing about the same number of weeks of training; Base I had reported costs much higher than those at Base H where the training load was substantially

Figure 1
Costs vs. Student Weeks



the same. Admiral Baker was not personally familiar with the way records were compiled at each base, and some of the numbers on his desk struck him as odd in view of his intimate knowledge of operations at all bases.

It occurred to him that some bases might be including (or excluding) different cost items; there might be reporting errors; one or more of the bases might be reporting abnormally high costs because its physical plant was notably under- or over-utilized, or bases might be improperly staffed for their workload. Until such possibilities had been "checked out" and any necessary adjustments made, he would not be ready to compute an equation from which costs could be estimated for varying training loads.

But such a complete reexamination of the underlying numbers would take more time than was available before his crucial budget interview. Moreover, a rough approximation of the trend line relating cost differences to size differences would help identify which base statistics were suspect and needed to be reexamined. Accordingly, Admiral Baker used the numbers in Table 1 to make some additional calculations which are set out in Table 2.

First he computed the average cost of providing a week of flight training at each of the nine bases as well as the overall average cost per week for the nine base training command as a whole. He noted that the four bases with the lowest training volume all had reported costs per

Table 2

	Number of Student Weeks	Total Cost	Average Cost Student Week	Deviation from Average Cost of Student/Week
	(1)	(2)	(3)	(4)
TOTAL	98,580	$12,529,900	$127.20	
AVERAGE	10,953	1,392,211	127.20	
TRAINING BASES WITH COSTS/STUDENT WEEK ABOVE AVERAGE				
A	8,306	1,199,500	144.40	+17.20
B	10,185	1,387,400	136.20	+ 9.00
C	10,191	1,377,000	135.10	+ 7.90
D	10,540	1,362,200	129.20	+ 2.00
SUBTOTAL	39,222	5,326,100		
AVERAGE	9,805	1,331,525	135.76	+ 8.56
TRAINING BASES WITH COSTS/STUDENT WEEK BELOW AVERAGE				
E	10,828	1,246,600	115.10	−12.10
F	11,094	1,392,500	125.50	− 1.70
G	11,716	1,383,400	118.00	− 9.20
H	12,782	1,534,400	120.00	− 7.20
I	12,918	1,646,900	127.00	− 0.20
SUBTOTAL	59,338	7,203,800		
AVERAGE	11,868	1,440,760	121.40	− 5.30

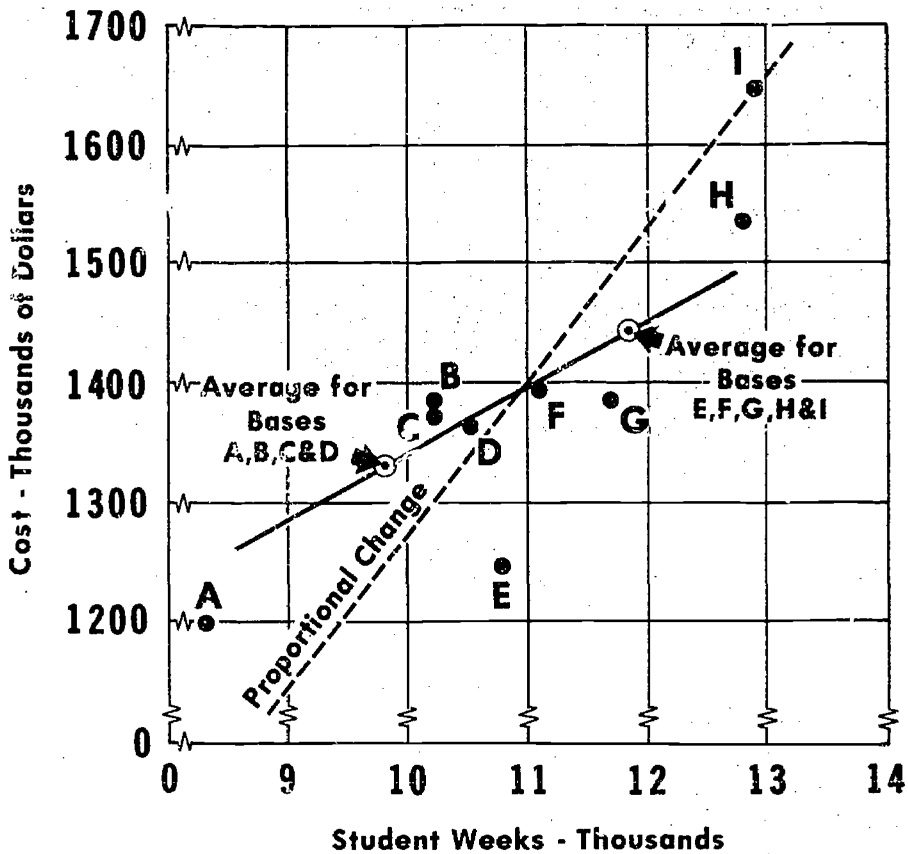
student week higher than the nine base average while the remaining five had all reported costs at least somewhat lower than average. This seemed to show that the deviations from average (Column 4) bore a significant relationship to the number of weeks of training provided by the reporting bases, but no uniform trend was apparent since other variations among individual bases obscured the relationship.

To get a "quick and dirty" approximation of a trend line relating cost to output over the relevant range of student weeks, Admiral Baker computed separate sub-totals for aggregate costs and weeks of training offered at the four bases which reported above-average costs (A, B, C, and D) and at the five bases reporting below-average costs (E, F, G, H and I). He then calculated the average number of student weeks and operating costs for each of the two groups. In Figure 2, he plotted these "above-average" and "below-average" cost/output observations and connected them with a solid line which also passed through the grand average cost/output point for the nine-base complex. This straight line gave him a rough approximation of the dollar costs which might be expected for varying operating levels *solely* on the basis of size (number of student weeks).

Then, since his immediate purpose in drawing the trend line was to discover whether operating costs for training student pilots would rise or fall more or less than changes in the number of pilots trained, he gave himself a visual reference by also constructing on Figure 2 a dotted "proportional change" line. If changes in operating costs were exactly proportional to changes in student load, a 20 percent increase in training weeks (from 10,953 to 13,140) should of course be accompanied by a 20 percent increase in costs (from $1,392,211 to $1,670,653). Conversely, a 20 percent decline (to 8762) should entail costs of $1,113,769. Any observation on the "proportional change line" passing through these points would represent the same average cost of $127.20 per student week as that computed for the previous year's operating level.

An actual cost/output trend line steeper than

Figure 2
Costs vs. Student Weeks



this "proportional change line" would indicate an activity in which *small* operating units were more efficient than large ones. But a flatter trend line—like the solid line in Figure 2—indicated a cost advantage for larger bases with higher operating levels—indicated, in short, that pilot training (at least over the relevant operating range) was an activity in which costs increased less than proportionally as output rose. And conversely, of course, as output (in this instance, number of student weeks annually) declined, costs would decrease, but *less than proportionally*. Unit costs (costs per student week) would rise because at the lower operating level, resources would be used less efficiently.

If, for instance, the proposed 10 percent reduction in number of student pilots cut the nine-base average training load from 10,953 student weeks to 9858, the aggregate costs associated with that level on the solid trend line would decline from the actual nine-base average of $1,392,000 to about $1,330,000—an indicated saving of only 4.5 percent.

Rough as this approximation of cost/output relationships at the nine-base training complex was, Admiral Baker felt he could say with confidence that any decline in number of trainees which significantly *lowered* operating levels at each of the nine bases would result in higher training costs per student week because bases with smaller numbers of students would be operating less efficiently. It seemed probable that a 10 percent cutback, absorbed proportionally among the nine bases, would reduce operating costs less than 5 percent.

On the other hand, if operating levels at individual bases could be maintained, there need be no decline in efficiency. (This assumes no change in costs due to price and wage inflation.) If one base were to be closed entirely, it would seem that the remaining eight should be able to handle the reduced total number of students at no increase in cost per student week because each would continue to operate at its current level. This was a highly significant finding, but Admiral Baker realized that any decision to close one of the nine bases would have to be taken at a higher level and he could not propose this solution without demonstrating clearly the cost advantage of such a course. The relationships presented in Figure 2 would supply only part of this documentation.

Turning again to Table 2, he noted that the smallest base (Base A) had—as might be expected—provided the most costly training: $144.40 per student week, $17.20 more than average. This was not a reason for criticizing the base commander since total costs for Base A—as plotted on Figure 2—were actually somewhat *below* those which the solid trend line might have predicted solely on the basis of the low student load.

On the basis of last year's cost figures, a quick calculation showed Admiral Baker that closing Base A would eliminate 9.6 percent of total operating costs—substantially the amount of the proposed budget cut—while reducing the number of training weeks available by only 8.4 percent.

This calculation was especially interesting to Admiral Baker since it suggested that he might, by concentrating his reduced enrollment at the bases which were able to provide training most efficiently, be able not only to absorb a 10 percent budget cut but also to give the smaller number of students a slightly longer training program.

He began to ask himself other questions. Could average costs per week be reduced further by distributing the entire workload among only seven bases rather than eight? (This would mean annual training loads in excess of 12,500 student weeks per base.) Would operating costs per student week continue to decline indefinitely as a base's training load expanded, or could he identify a "best size" of flight training facility within the range covered by the data in Table 2? Might some bases already be beyond that point, and could savings be effected by reassigning some students to those with under-utilized capacity? In short, could the cost/output information now on Admiral Baker's desk show him how to cut the cost of providing a week's training by reallocating the workload within his command?

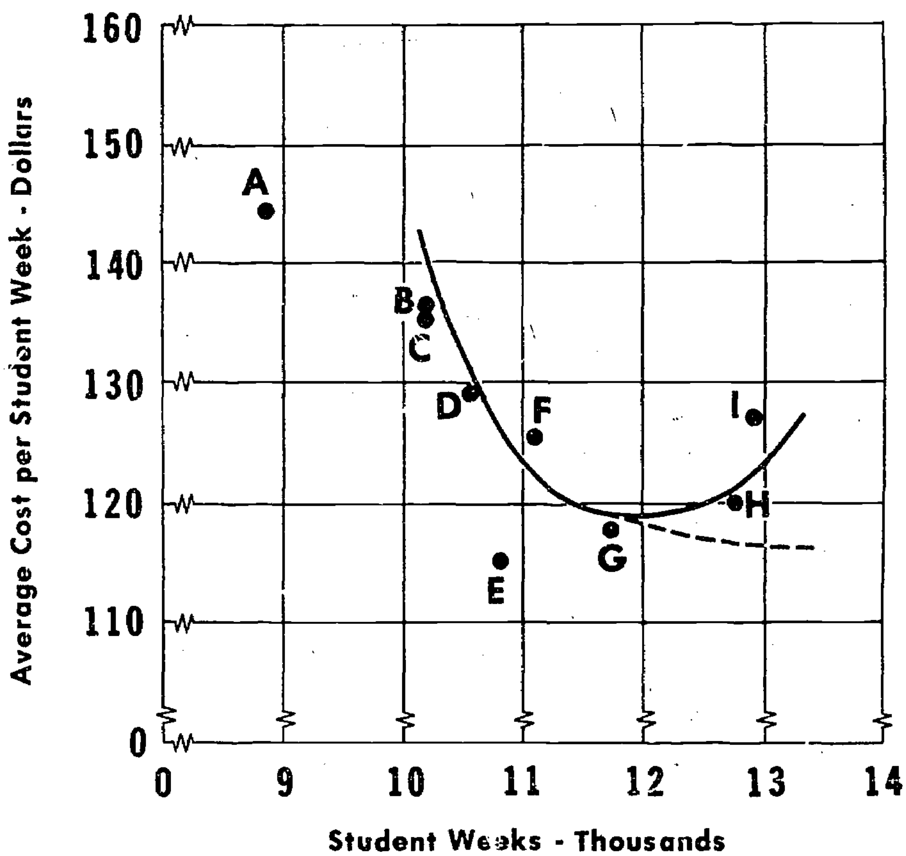
Figure 3 suggested some interesting possibilities in answer to these questions. On this chart, Admiral Baker plotted cost/output observations to show—not aggregate operating costs as in Figures 1 and 2—but *costs per student week* at bases with differing annual training loads. While the larger bases in the command were, in general, less costly to operate on this basis than the small ones, it was reasonably clear to Admiral Baker that if cost data were accurate as reported for all the bases in his command, increasing the number of student weeks at an individual base would not continue indefinitely to reduce cost per student week. Indeed, these data, as plotted in a scatter diagram on Figure 3, suggested that the two bases with training loads in excess of 12,500 weeks annually might already be at least slightly beyond the most efficient operating level.

Using observations for the eight bases at which he proposed to concentrate next year's reduced student load, Admiral Baker visually fitted an average cost curve showing a low-cost operating level in the range of 12,000 student weeks per year. As in Figure 2, costs reported at Bases E and I appeared to be notably "out of line" with those at the other bases: the cost differentials could not be accounted for primarily in terms of size variations. Costs reported for Base E were exceptionally low while those at Base I were far higher than at Base H which operated at almost the same level.

Before making dollar and cent estimates for next year's budget, Admiral Baker would need to find out what accounted for these differences. If they were simply reporting errors, the cost figures themselves would need to be revised. If Base E enjoyed special cost advantages (climate? local labor costs? or whatever) it might be desirable to concentrate a larger share of the training program there. Individual instances of management problems or superior management

Figure 3

Average Cost per Student Week



might also appear in checking "out of line" observations.

The figure for Base I particularly surprised Admiral Baker since he was familiar with its operation which seemed highly efficient. It occurred to him that the numbers for this base might not really be comparable with the others, that costs assigned to pilot training at Base I might actually include as well outlays for another function also carried out there. If this had, in fact, occurred, average weekly costs attributable solely to pilot training at Base I might be considerable lower— perhaps even lower than those at Base G. In that event, the average cost curve he had drawn, instead of turning up around the 12,000 student week level (as indicated by the solid line) might instead flatten out or even continue downward. (He added a broken line to indicate this possibility.)

This was a question of fact to be investigated, but for his present calculation, Admiral Baker accepted the data before him which suggested that the most efficient operating level for these bases with their existing facilities was in the range of 12,000 student weeks per year. When any necessary adjustments for Bases E, I, and possibly F had been made, Admiral Baker could have a precise curve fitted mathematically to the eight observations, but if revisions simply tended to bring data for these bases "into line" with the pattern already established by the other observations, his visually fitted curve might be quite adequate for allocating students throughout the training complex.

According to the solid line in Figure 3, there would be an advantage in concentrating training at bases in the 12,000 student week size range, but how significant, he wondered, would the cost differentials be? Some very simple marginal analysis quickly demonstrated the value of making all feasible shifts. In the previous year, for instance, Base D had provided 10,540 student weeks of training for $1,362,200. Base F had handled 11,094 weeks for $1,392,500. The average cost of $129.20 at Base D seemed only moderately higher than the $125.50 outlay at Base F for a similar accomplishment. But focussing attention on "marginal" rather than "average" costs showed that Base F was able to provide the *additional* 554 weeks associated with its heavier teaching load for only $30,300 additional outlay; the *marginal cost* of those additional student weeks was only $55 per week.

Conversely, the apparent "penalty" for providing 12,782 student weeks of training at Base H as compared with 11,716 weeks at Base G was a mere $2.00 differential in average costs—$120 per student week versus $118. But the added cost of providing the 1066 *additional* student weeks at Base H was $151,000 ($1,534,400 versus $1,383,400) or $141.00 for each of the added student weeks. If, after reexamining data for Base I, it still appeared that the average cost curve did in fact turn up around the 12,000 student week level, this marginal comparison indicated there might be significant diseconomies from assigning individual bases training loads beyond their most efficient operating levels.

His limited data suggested to Admiral Baker that bases operating at about the 12,000 student week level, should be able to conduct pilot training for an average operating cost of $118 per student week. Admiral Baker did a quick calculation: at that rate, even the reduced budget would let him provide 95,567 student weeks of training as compared with 98,580 last year—a reduction in student weeks of only 3.1 percent. Distributed among only eight bases, 95,567 student weeks would give each base a training load at or near the apparent low-cost point as suggested by Figure 3, and next year's smaller number of student pilots would each be receiving nearly 8 percent *more* training time. All this might be permitted by the "savings" generated through a more efficient allocation of training loads.

Admiral Baker had no illusions that the favorable result promised by his "quick and dirty" computation could be fully realized in practice, but the analysis did convince him of two things. First, to operate the nine existing training bases with a smaller number of students assigned to each meant less efficient operations at most of these bases and would significantly increase the average cost per student week for the command as a whole. Second, if he were authorized to close the least efficient of the nine bases and given a free hand to achieve the most efficient operating levels at the remaining eight through student assignment, he might be able not only to live with a 10 percent budget cut but also to lengthen the training period for the reduced number of student pilots. Neither of these possibilities had been apparent from his initial inspection of the cost/output data assembled in Table 1.

Use Made of the Analysis. Admiral Baker's initial budget interview did not result in an immediate decision for the coming year. On the basis of the evidence he presented, the Budget Officer accepted both of Admiral Baker's conclusions and agreed that the least costly solution—at least in terms of operating costs—would be to close Base A and reassign students as Admiral Baker proposed among the remaining eight. He agreed to recommend this proposal, with the additional understanding that any savings Admiral Baker might effect over and beyond the 10 percent budget cut could be applied toward some lengthening in the training program as Admiral Baker sought.

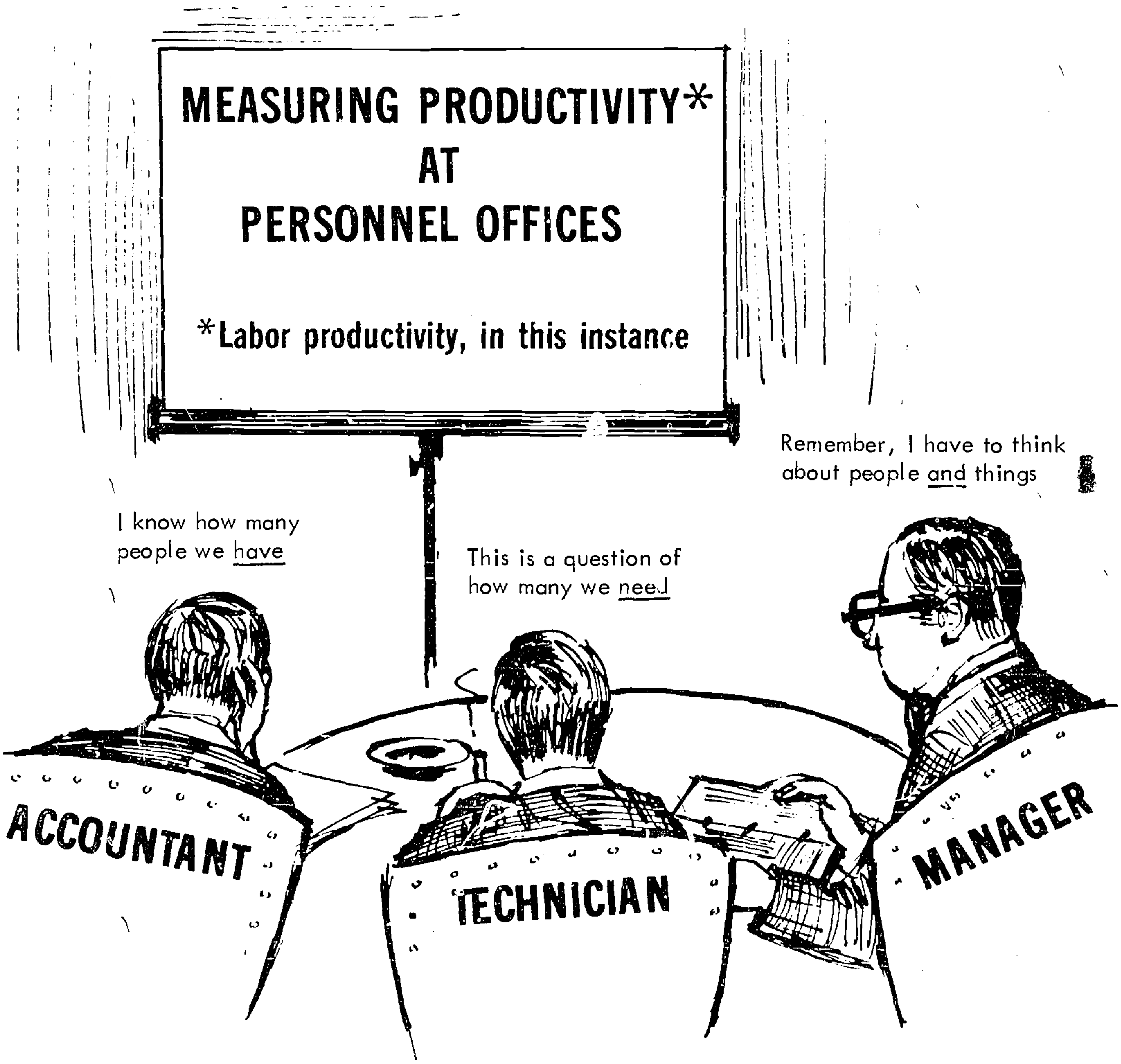
At the same time, he cautioned Admiral Baker that closure of Base A might not be practical. The closure itself would entail costs which, though they would not figure in Admiral Baker's operating budget, must be taken into account at a higher level—particularly if it appeared that the reduction in number of student pilots might be temporary. Moreover, impact of the closing on the local community and other factors would have to be considered. Consequently, Admiral Baker should be prepared to furnish a detailed estimate of the costs which would be incurred for training next year's reduced number of student pilots at all nine bases.

Admiral Baker agreed to prepare this estimate as soon as he had "clean data"—i.e. had received adequate answers to his questions concerning records and operating costs at the bases where costs were conspicuously "out of line" according to his preliminary analysis. He reemphasized that he expected the final estimates for a training program cut by 10 percent to show costs down by 5 percent or less. If final estimates did confirm this expectation, the budget officer agreed to recommend approval of the minimum needed to maintain present program quality.

More Questions—More Analysis. Admiral Baker returned to his own desk eager to "get on with his homework." His interest was not so much in establishing a more precise relationship between costs and operating levels. He was hopeful that top level decision makers would favor concentrating training at eight bases, so that the precise estimating equation he and the Budget Officer had discussed would not be needed. Rather he was eager to learn why costs at some bases appeared to be so greatly "out of line" with the performance his preliminary analysis had indicated on the basis of size.

Was Base E operated more efficiently than the other bases, and if so, could operations officers at other bases adopt the same procedures? Were facilities at Base I being over-utilized, or were cost data, as recorded, simply overstating costs attributable to pilot training? Might revised data show that some further increase in the number of training weeks provided at the larger bases would in fact *lower* rather than raise their average costs? If so, might he find ways to increase further the length of training given his student pilots? Admiral Baker had already identified a number of useful relationships from the cost/output numbers presented in Table 1, but he realized what he had been able to do with those numbers so far was only the beginning of "analysis." Much more needed to be done.

III - 3


MEASURING PRODUCTIVITY*
AT
PERSONNEL OFFICES
*Labor productivity, in this instance
I know how many people we have
This is a question of how many we need
Remember, I have to think about people and things
ACCOUNTANT
TECHNICIAN
MANAGER

CASE HISTORY 3: MEASURING PRODUCTIVITY AT PERSONNEL OFFICES

The Situation. Mr. Dodd was working in the Management Analysis Section of the Comptrollers Office when a problem arose concerning the staffing of civilian personnel offices. The Department of the Army had established an explicit standard for staffing such offices. This standard called for an over-all ratio of one personnel office employee for every 88 civilians employed at the establishment which the office served. A recent survey had shown that personnel offices at manufacturing arsenals, as a group, were "over staffed" according to this standard.

Fifteen such arsenals had a total civilian payroll of 52,800, while the associated personnel offices reported 622 employees—a ratio of one personnel office employee for only 84.9 civilian employees at the fifteen arsenals. Reaching the established ratio would require a reduction of 22 in the total number of personnel office positions authorized. Since Mr. Dodd had had considerable experience with the work done in civilian personnel offices, he was given the assignment of recommending how this reduction should be spread among the 15 offices involved.

The Numbers. On receiving this assignment, Dodd immediately asked what information was available for his analysis and was told, "You're looking at it." His superior handed him a paper listing the number of employees in the personnel office at each armory and the total number of civilian employees at the same installation. "At least you'll be able to find the employee ratio at each office and then cut back on the ones that are out of line," his boss told him.

"I hope that's a joke," Dodd protested. "Knowing how many employees an arsenal has doesn't tell us how much work its personnel office is doing."

"It won't be a joke," answered his superior, "unless you find a better way of comparing the workloads those fifteen offices handle."

Dodd's first step in carrying out this assignment was to visit the personnel office at Arsenal Number 8, the nearest of the fifteen. After talking to staff members and examining the way the files and other records were kept, he prepared a short questionnaire. It covered three separate types of personnel department activity over the preceding year: the number of personnel actions taken (accessions, changes and separations); the number of positions analyzed and evaluated by the department; and the number of hours of off-the-job training sessions conducted. He then gave this data format, together with written instructions for its completion, to a staff member at Arsenal Number 8 who was able to fill out the form for his department in one day.

Since Dodd was now in a position to show that the numbers he sought from each personnel office could be assembled with only about eight man-hours labor, he was able to secure the Comptroller's authorization for extending the survey to the other arsenals. This he did and soon was in possession of the output data he had requested from each of the fifteen arsenals.

The 15 questionnaires enabled him to compare directly the number of personnel actions processed in each office during the preceding year; likewise, he could compare all personnel offices in regard to the number of job classifications and evaluations made and in regard to the amount of off-the-job training offered. But these three separate comparisons each represented only part of the personnel activities carried out at all the offices. Moreover, on inspecting the reports, he saw that the relative importance of the three activities clearly differed from office to office as a share of total "output."

In order to compare the workloads handled at various arsenals, he needed a common denominator for the three measures of differing kinds of output. A composite measure of "work units" which combine dissimilar activities is, by definition, abstract. Also by definition, its accuracy depends on the judgment of the person who decides how to "weight" the diverse units of physical measurement: one job classification analysis represents more work than processing a routine personnel action, but how *much* more work?

On the basis of his own familiarity with civilian personnel work, Dodd established a tentative scale for converting his three dissimilar sets of output numbers into a common measure of "work units." Then he checked his proposed scale with several experts in the field and made modifications in accordance with their suggestions. Finally, he converted the three "out-

Table 1

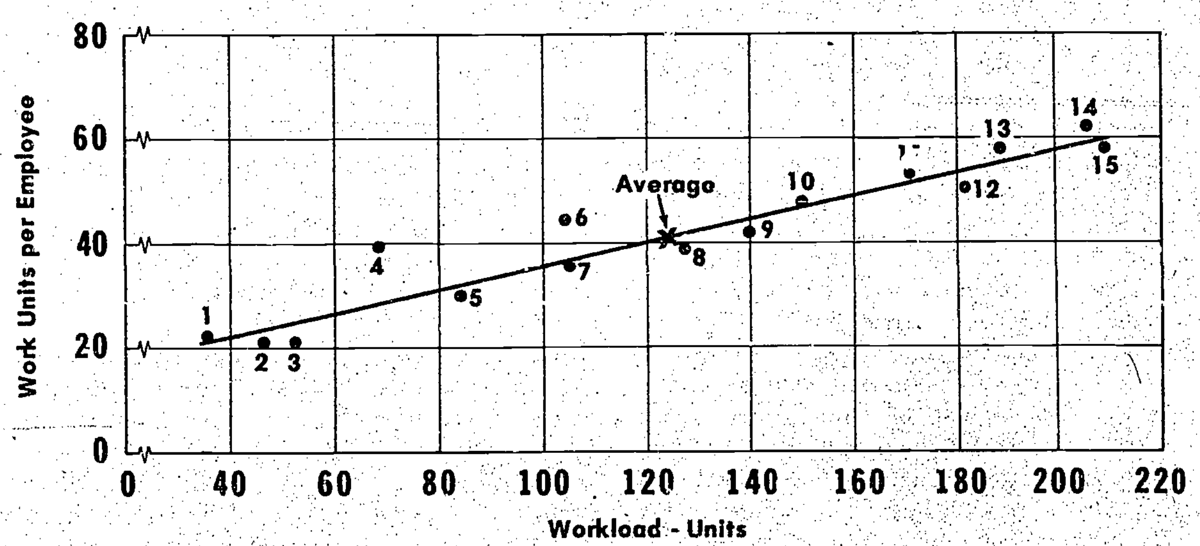
Arsenal	Work Done (Units)	Number of Employees (Personnel Department)
1	35	22
2	46	21
3	53	21
4	68	39
5	84	29
6	104	44
7	105	36
8	127	39
9	139	42
10	149	47
11	171	53
12	181	51
13	187	58
14	207	62
15	210	58
Total	1866	622
Average	124	41

puts" reported for each office into uniformly defined "work units" which could be matched with the labor force at each arsenal as shown in Table 1. At this point, he was in a position to compare manpower utilization at the fifteen personnel offices.

The Analysis. The first step in Dodd's analysis was to plot his manpower/output observations for the fifteen arsenals on a scatter diagram showing the units of work handled at each personnel office on the horizontal axis and the number of employees performing it on the vertical axis. (See Figure 1.) Higher workloads were clearly associated with larger work forces and the relationship appeared, by inspection, to be linear. Accordingly, Dodd had a straight-line regression equation calculated for the fifteen manpower/output observations and added the regression line shown in Figure 1. (If statistical facilities had not been available, Dodd might have based his analysis on an approximation of this regression line. One way to make such an approximation would have been to calculate the average workload (124 work units) and the average staff (41 employees) for the 15 offices and plot this average observation on the scatter diagram (Point X on Figure 1.) He could then have selected visually the line passing through this point which seemed to give the best fit for the 15 manpower/output observations by rotating a ruler through Point X. The slope decided on in this fashion would not have been as precise as the line fitted statistically by the regression equation, but it would have permitted much the same analysis.)

For most of the observations, this line provided a good fit; that is, the actual staffing of

Figure 1



most personnel offices was rather close to the number of employees which might have been predicted on the basis of workload as reported at those offices. But two notable exceptions immediately attracted Dodd's attention. Arsenals #4 and #6 both appeared to need—or at least to employ—significantly more people in their personnel offices than their workloads seemed to warrant.

This did not, in itself, indicate that these offices were overstaffed since either or both might confront special circumstances requiring more employees. But the differences between actual staff and the number predicted for these output levels by the regression equation warranted investigation. The equation provided a standard for manpower utilization based on experience at all fifteen personnel offices. If these two "out-of-line" offices could improve operating procedures enough to achieve that standard, they could absorb substantially the entire proposed cutback in authorized positions without impairing performance.

Dodd was greatly encouraged in this regard by his investigation of circumstances at Arsenal #4 where the actual number of employees was 39 compared with an "expected" staff of 29. It developed that the workload at this personnel office had been declining, partly due to a cutback in civilian jobs at the arsenal but more importantly to reduced turnover among the remaining work force which consisted predominantly of long-term employees. The personnel director, confronted with his office's relatively unfavorable performance, reviewed procedures and concluded that his current workload probably could be carried out with "average" staffing. If so, about half of the required reduction in total force could be absorbed at this one office without loss of output.

A visit to Arsenal #6, however, was less encouraging. Arsenal #6 suffered by reason of being at an isolated location, high turnover of civilian employees and a continuing need for active labor recruitment outside the local area. This was a major and time consuming function of the personnel office—and one which had *not* been included in the composite work units measured by the survey. Dodd concluded that the local personnel director would be confronted with serious problems in doing his work if even one position were abolished in this office.

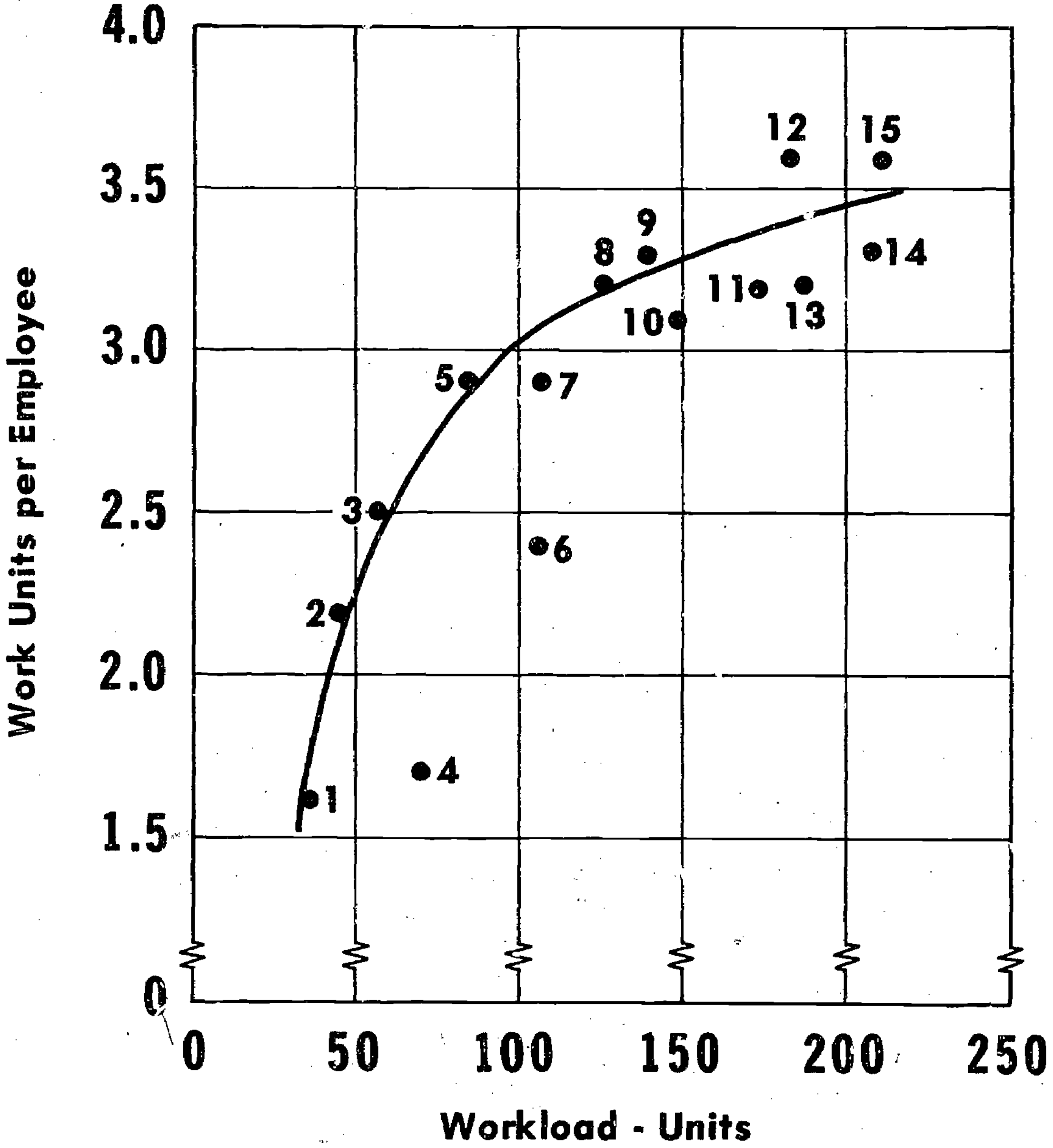
Since the regression analysis had not suggested serious overstaffing at any other office. Dodd recognized that the further cuts still needed to achieve an 88 to 1 employee ratio might well reduce—at least somewhat—the ability of personnel offices to handle their current workload. His problem now was to identify specific offices at which such an outcome might be avoided. With this objective, he turned back to the data in Table 1 and added a column showing work units per employee at each personnel office. (See Table 2.)

Table 2

Arsenal	Work Done (Units)	Number of Employees (Personnel Department)	Work Units Per Employee
1	35	22	1.6
2	46	21	2.2
3	53	21	2.5
4	68	39	1.7
5	84	29	2.9
6	104	44	2.4
7	105	36	2.9
8	127	39	3.2
9	139	42	3.3
10	149	47	3.1
11	171	53	3.2
12	181	51	3.6
13	187	58	3.2
14	207	62	3.3
15	210	58	3.6
Total	1866	622	...
Average	124	41	3.0

This new column showed that large offices were, in general, more efficient than smaller offices, that is, more work was accomplished per employee. This information, in itself, was not directly relevant to Dodd's recommendation since there was no prospect for consolidating or redistributing workload among fifteen personnel offices serving different arsenals. Nevertheless, he hoped that these figures on average output per employee might help him identify some offices which should be able to increase worker productivity. So he drew another chart plotting these numbers for each office against the office's total workload (See Figure 2.) And then he drew in, by hand, a rough curve to fit the scattered points. This visual curve suggested that output per employee increased very rapidly with expanding office size up to a work load of about

Figure 2



100 composite work units but much more gradually for larger scale operations.

As in Figure 1, the relatively poor performance of offices #4 and #6 was highlighted. But what struck Dodd particularly about this diagram was the notable differences it revealed among the largest offices. Personnel offices at arsenals #12 and #15 showed strikingly higher productivity (3.6 work-units per employee) than those at #'s 11, 13, and 14 with roughly comparable work loads. He checked out the possibility that the latter offices faced special problems—such as the ones affecting staff needs at arsenal #6—and found no evidence that work requirements were in any way unusual.

A brief calculation using the data in Table 2 indicated that an increase in productivity from 3.2 to 3.5 units per worker at arsenal #11 would enable that office to dispense with four employees without sacrificing output. Similarly, if offices #13 and #14 could raise their productivity to 3.6 units per worker (matching the performance at offices #12 and #15) staff needed to handle the current workload could be reduced by 6 and 4 positions respectively. These cutbacks would be more than enough to achieve the required 88 to 1 overall ratio among personnel office and other civilian employees for the 15 arsenals.

Use Made of the Analysis. The following week, a meeting was held in the Comptroller's office to formulate a proposal for the Director of Civilian Personnel recommending which personnel offices should be asked to absorb a reduction in staff totalling twenty-two positions.

It was quickly agreed that only one office—that at arsenal #4—appeared significantly overstaffed on the basis of Mr. Dodd's analysis. The recommendation that employment at this office be brought "into line" with its current work load—a step already anticipated by the office director—would provide about half of the required reduction.

Beyond this, it was not clear from the information at hand whether or not the additional positions could be eliminated without at least some adverse impact on the amount or quality of work done at the offices affected by the cuts. There were wide variations among offices in productivity (work units per employee), but these appeared to be related largely to size differentials rather than inefficient utilization of manpower at particular offices. In fact, the evidence suggested that small offices, which generally reported the lowest output per employee, would have very limited ability to compensate for staff reductions by increases in productivity.

If, on the other hand, the cutbacks Dodd suggested were ordered at arsenals #11, #13 and #14, and they protested, it could be pointed out to them that the personnel offices at arsenals #12 and #15 were already handling comparable workloads with the level of staffing now being proposed. If arsenals #11, #13 and #14 matched that performance standard, the desired employee ratio could be reached without any reduction in activities carried out by the entire group of personnel offices.

Accordingly, the response forwarded to the Director of Civilian Personnel recommended reducing authorized positions at the following offices:

Arsenal	Reduction	New Authorization
4	−10	29
11	−3	50
13	−5	53
14	−4	58

More Questions, More Analysis. As the meeting concluded, the Comptroller expressed satisfaction that Mr. Dodd's study had produced such a direct and workable answer to the question raised by the personnel director.

"This answers the question we were *asked*," Dodd commented, "but I wonder whether we were asked the right question."

"You identified a way of getting the same work done with fewer people, didn't you?" was the response.

Dodd shook his head. "We ought to be looking for ways to do the work at the lowest *cost*—not just with the fewest *bodies*. This analysis didn't go into salary ranges, and it didn't even consider equipment or other costs. We don't know whether reducing the number of positions at these offices will reduce their *total* costs." The meeting broke up without any further discussion.

Several months later when budget estimates were being reviewed, Dodd was called to the Comptroller's office and reminded of that conversation. The Comptroller had in hand budget requests for data processing equipment to be installed at several civilian personnel offices. Dodd recognized the group as including those at manufacturing arsenals #11, #13 and #14.

"The justification statement reads, 'Required in order to handle the workload with limited staff,' the Comptroller remarked and then added, "it is also noted here that data processing systems of the type being requested had been installed earlier in two personnel offices where they are functioning very successfully."

"Where?" Dodd asked.

The Comptroller paused and smiled. "Those offices," he said, "are located at arsenals #12 and #15."

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